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GEOLOGY OF THE LAC VERNON AREA (34J)

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Martin Parent
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Kamal N.M. Sharma
Pierre Lacoste

Accompanies map
SI-34J-C2G-02A

Porphyritic metalavas of the Chavigny Complex.

2003

Québec

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Martin Parent
Alain Leclair
Jean David
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Pierre Lacoste

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(Accompanies map SI-34J-C2G-02A)

Abstract

The Lac Vernon area, bounded by latitudes 58°00' and 59°00' north and longitudes 74°00' and 76°00' west, is represented by NTS sheet 34J. It covers a surface area of about 13,000 km^2. The centre of the area is located 175 km east of the community of Inukjuak, and about 140 km from the coast of Hudson Bay. The geological survey carried out at 1:250,000 scale was conducted within the scope of the Far North mapping project spearheaded by Géologie Québec.

Archean rocks in the Lac Vernon area were subdivided into different lithological and lithodemic units. Volcano-sedimentary rocks are concentrated in the Chavigny (2722 Ma) and Kogaluc (< 2759 Ma) complexes, whereas sedimentary rocks in the central part of the map area were grouped in the Le Roy Complex. Elsewhere, a few bands several kilometres in size, mainly composed of paragneiss with a few mafic gneiss outcrops were grouped in a lithological paragneiss unit. Tonalitic rocks belong to the Rochefort (2769 Ma) and Kakiattuk (2740 Ma) suites, whereas foliated and granoblastic gabbros, diorites and gabbronorites are associated with the Bacqueville Suite. Granodiorites of the Rivière-aux-Feuilles Suite (2722 Ma) are found in the vicinity of the Kogaluc Complex, as well as in the northwestern part of the map area. The other plutonic rocks are represented by the Qilalugalik Suite (2709 Ma), the Lac Minto Suite (*ca.* 2700 Ma), the Morrice Suite (2682 Ma), the Qullinaaraaluk Suite and the Le Roy Complex (2698 Ma).

The Lac Vernon area is characterized by the presence of five aeromagnetic patterns, with orientations ranging from N-S to NW-SE. Each of these anomalies is characterized by distinct lithological associations and different geological settings and structural styles. Rocks in the Lac Vernon area reflect a complex structural setting that results from two phases of ductile and folding deformation (D_2-D_3), a phase of intense shearing (D_4) and a phase of brittle deformation (D_6). A penetrative foliation (S_2) is present in all the rocks in the area with the exception of those of the Qullinaaraaluk Suite and diabase dykes. Ovoid shapes suggest the presence of structural domes (doming effect) whose formation is coeval with the emplacement of plutonic rocks and D_2 deformation. The structural evolution is associated with pre- to post-tectonic intrusive events that mask contact zones between certain geological assemblages. It is also characterized by amphibolite and granulite facies regional metamorphism.

The economic potential of the area was namely outlined by the discovery of the Qullinaaraaluk Ni-Cu-Co showing located in the area that corresponds to the southern map sheet (NTS 34G). It consists of m-scale massive and semi-massive sulphide pods hosted in a late intrusion of pyroxenite and peridotite (Qullinaaraaluk Suite). Samples collected during the mapping campaign yielded grades reaching up to 2.6% Ni, 1.8% Cu and 0.27% Co. Several mafic and ultramafic intrusions similar to the Qullinaaraaluk intrusion were mapped in the Lac Vernon area. Elsewhere, the Chavigny Complex contains anthophyllite-cordierite zones associated with volcanic rocks, which host anomalous gold and base metal grades. These zones appear to represent basalts affected by volcanogenic hydrothermal alteration. Finally, the gold potential of the area had already been confirmed in the Kogaluc and Narsaaluk iron formations. Grades reaching up to 61 g/t Au were obtained during exploration programs conducted by Soquem, Cominco, Virginia Gold Mines and Cambiex since 1993.

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INTRODUCTION

The northeastern part of the Superior Province is formed of partially reworked continental crust, where a remarkable record of the tectonic and geologic history of the Archean has been preserved. It constitutes the largest extent of Archean rocks whose geology is only partially known, and whose mineral potential remains little explored. It occupies a surface area of about 320,000 km^2, located north of the 55th parallel. This territory corresponds to nearly 20% of the total surface area of Québec. Since 1998, the northeastern Superior has been the focus of an important geological mapping project undertaken by Géologie Québec, of the Ministère des Ressources naturelles (MRN). The purpose of the Far North project is to acquire new data on this vast territory (Leclair *et al.*, 1998). Its objectives are to establish a regional geological framework at 1:250,000 scale, to determine the nature, origin and tectonic evolution of this part of the Superior, and to assess its mineral potential by identifying geological settings favourable to the discovery of new mineral deposits. Over the last three years, 12 new geological surveys were conducted within the scope of this project, including a survey in the Rae Province (Figure 1). These surveys led to the discovery of numerous mineral occurrences as well as several new volcano-sedimentary belts that are remarkably well preserved (Leclair *et al.*, 2000). They also helped outline the most interesting geological settings in the search for specific ore deposit settings (Labbé *et al.*, 1998, 1999, 2000; Labbé and Lacoste, 2001; Moorhead *et al.*, 2000).

One of the recent geological surveys of the Far North project was carried out in the Lac Vernon area (NTS 34J) (Figure 1). This report contains the results and interpretations derived from geological mapping at 1:250,000 scale, carried out over the course of the summer 2000 in this area. The preliminary map, supported by complementary work carried out in the summer 2000 in the Lac Minto area (NTS 34G), is available in SIGÉOM (Leclair and Parent, 2000). The results of this work will be discussed in a subsequent report. The Lac Vernon area survey follows previous surveys conducted in the adjacent Lac Nedlouc area (NTS 34H; Parent *et al.*, 2000) and Lac La Potherie area (NTS 34I; Leclair *et al.*, 2001a). Mapping in these areas was namely useful to establish a stratigraphic and structural setting that served as a basis for regional correlations.

Location, Access and Topography

The Lac Vernon area is located in Nunavik, in the west-central part of the Ungava Peninsula (Figure 2). It corresponds to NTS sheet 34J, bounded by latitudes 58°00' and 59°00' north and longitudes 74°00' and 76°00' west. It covers a surface area of about 13,000 km^2 to the north of the Rivière aux Feuilles. The centre of the area is located 175 km east of the community of Inukjuak, and about 140 km from the coast of Hudson Bay. Several lakes in the area are suitable for floatplanes flying in from the air base in Kuujjuaq or Puvirnituq. The largest water body in the area, Lac Chavigny, is clear of ice in early July. A landing strip, suitable for short take off aircraft (Twin Otter type), is located on an esker near the southern shore of Lac Chavigny.

The Lac Vernon area lies in the Arctic tundra, more than fifty kilometres north of the forested tundra limit. It is characterized by a landscape scattered with small hills a few tens of metres high on average. Topographic relief is fairly flat, with a maximum altitude variation of one hundred metres. In the northeastern part of the area, the landscape is carved by steep and narrow valleys, producing somewhat sharper relief. The altitude increases slightly from the north southward, and ranges from 130 to 300 metres above sea level. Outcrops are generally numerous, large and lichen-covered, with the exception of a few sectors where felsenmeer glacial deposits extend over several tens of square kilometres.

Methodology

Geological mapping at 1:250,000 scale represents an efficient means to rapidly establish the geological framework of vast unknown territories. In order to obtain a complete geological inventory of the Lac Vernon area, fieldwork was carried out by six geologists extended over a period of 11 weeks, from early June to late August. Mapping crews each composed of one geologist and one assistant, were mobilized in the field by a 206-L Long Ranger helicopter from the base camp located on an esker near the southern shore of Lac Chavigny. Traverses, ranging from 8 to 12 km in length, were spaced every 4 to 10 km depending on the geological complexity and the density of outcrops. The survey spacing was reduced in areas considered as key sectors for geological correlations and mineral potential. On average, a dozen traverses were carried out in each 1:50,000 scale NTS sheet. Helicopter spot checks of about 150 sites completed the mapping coverage. Lithological units and mineralized zones were systematically sampled, and the samples were used for geochemical analyses, magnetic susceptibility measurements and thin sections. Seven samples were collected for geochronological analysis. These samples were processed at the GEOTOP centre of the Université du Québec à Montréal by Jean David, of Géologie Québec. The geological map of the Lac Vernon area, as well as data collected in the field and analytical results, are available in the SIGÉOM (Québec Geomining Information System) computer database managed by the MRN.

Previous Work

Prior to the 1990s, the only geoscience information available for the northeastern Superior Province was essentially restricted to the results of geological surveys carried out at

1:1,000,000 scale (Eade, 1966; Stevenson, 1968), and regional aeromagnetic and gravity surveys. During the 1990s, the Geological Survey of Canada conducted a geological survey at 1:500,000 scale along the Rivière aux Feuilles (Percival and Card, 1994) and three geological surveys at 1:250,000 in three areas further north (Percival *et al.*, 1995a, 1996a, 1997a) (Figure 1). The Vizien greenstone belt, located in the southern part of the Lac La Potherie area, was also mapped at 1:50,000 scale (Percival and Card, 1991). Furthermore, the MRN conducted a survey at 1:50,000 scale in the Lac Dupire area (Lamothe, 1997). In the summer 1998, within the scope of the Far North project, Géologie Québec mapped at 1:250,000 scale the Lac Peters area (Madore *et al.*, 1999), the Lac Nedlouc area (Parent *et al.*, 2000) and the Lac Gayot area (Gosselin and Simard, 2000), and in the summer 1999, the Rivière Arnaud area (Madore and Larbi, 2000), the Lac La Potherie area (Leclair *et al.*, 2001a), the Lac Aigneau area (Berclaz *et al.*, 2001) and the Lac Maricourt area (Simard

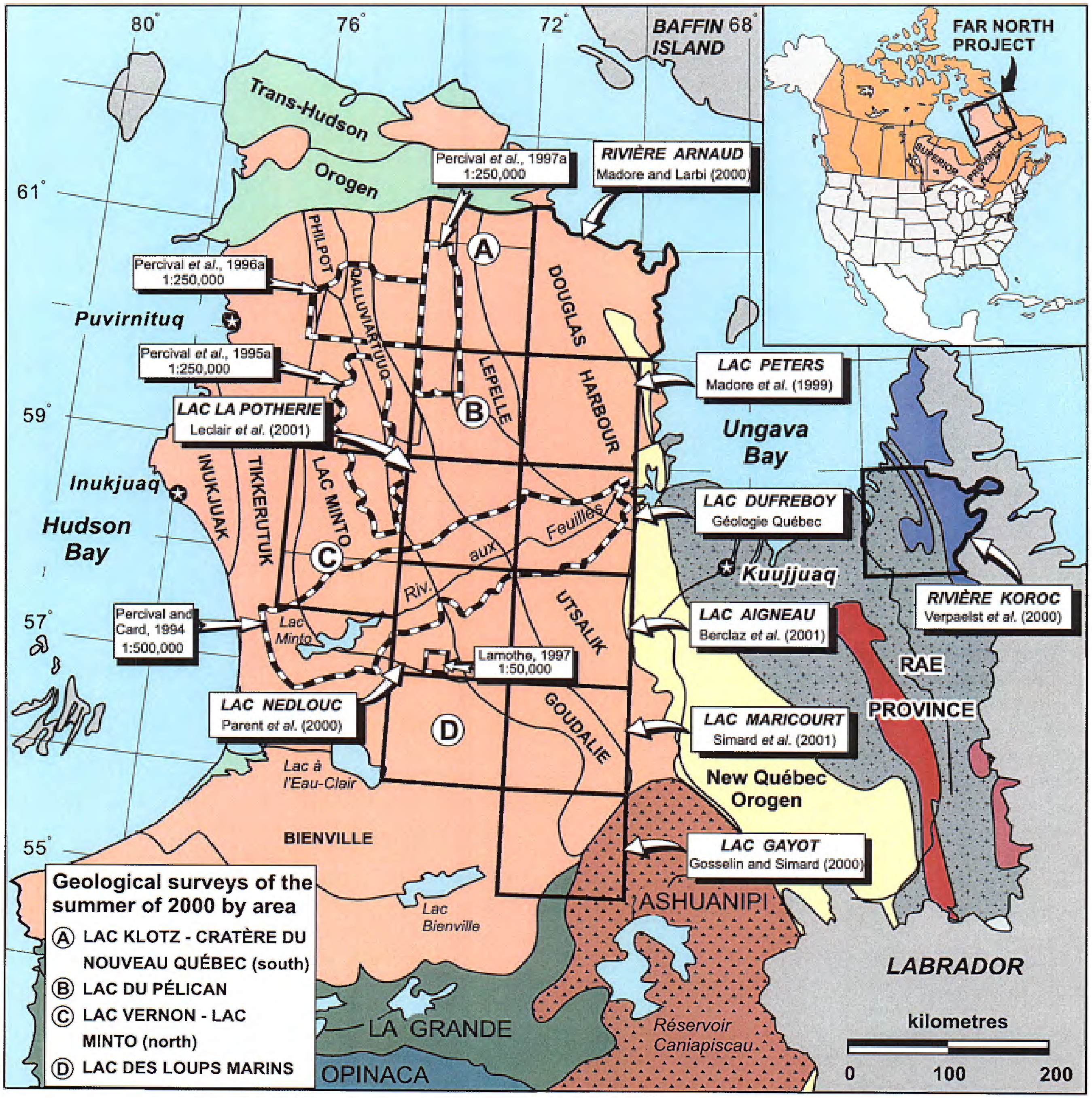

FIGURE 1 - Lithotectonic subdivisions of the northeastern Superior Province (modified after Percival *et al.*, 1997b) and location of recent geological mapping projects in the Far North.

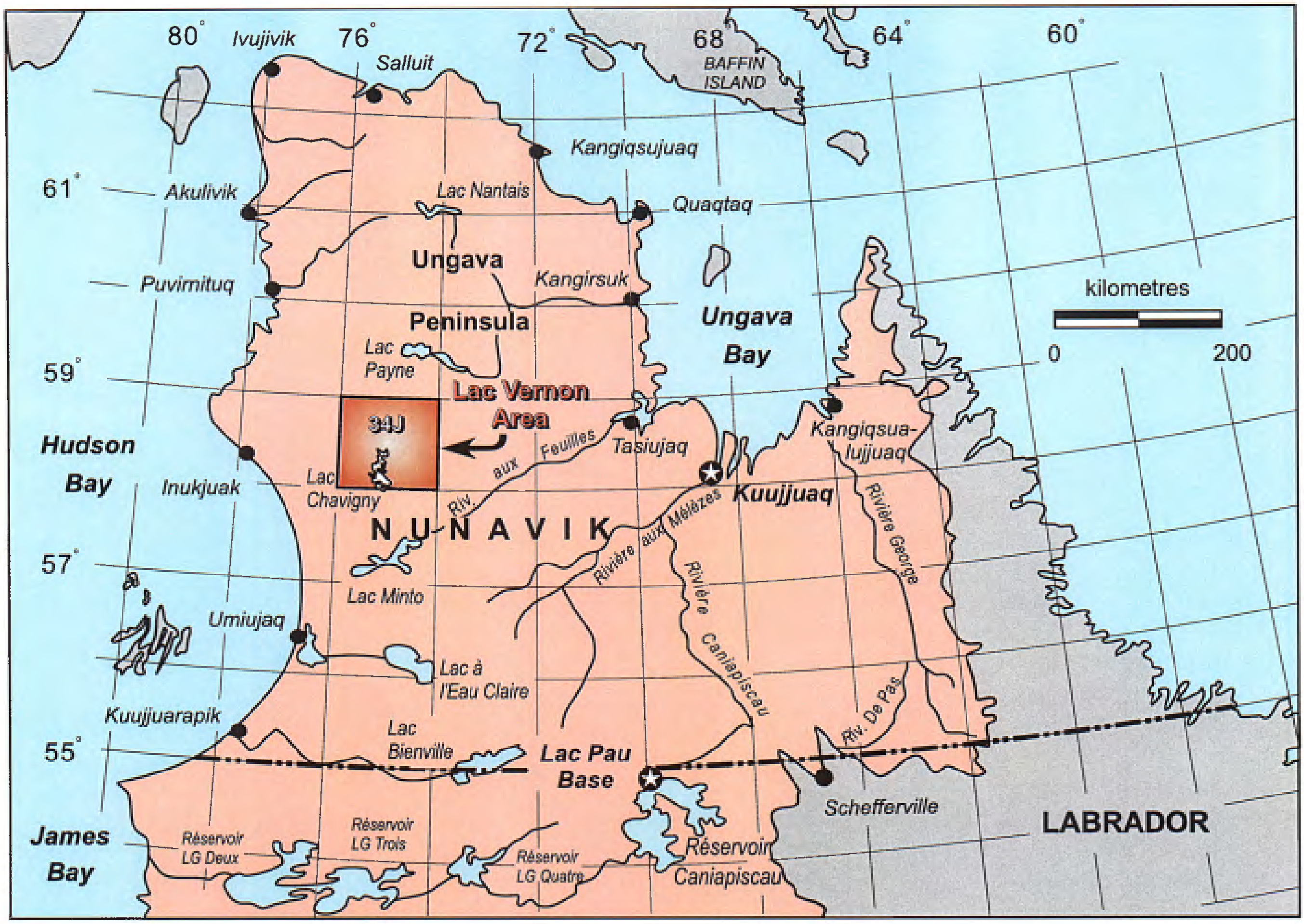

FIGURE 2 - Location of the Lac Vernon area.

et al., 2001) (Figure 1). During the summer 2000, the Far North team conducted four new geological surveys, including one in the Lac Vernon area, which partially overlaps the work of Percival *et al.* (1995a).

Since 1992, the Lac Vernon area has been the focus of exploration work by joint ventures involving mining companies such as Soquem, Virginia Gold Mines, Cominco and Cambiex. Assessment work reports outline a promising mineral potential, namely for gold and base metals, in many locations (Cattalani and Heidema, 1993; Chapdelaine, 1995, 1996, 1998; Francoeur, 1995, 1996, 1998; Francoeur and Chapdelaine, 1994, 1999; Grosl, 1993; Villeneuve and Chapdelaine, 1999). During the summer 1997, the area was covered by a lake sediment survey commissioned by the MRN, in partnership with five mining exploration companies (MRN, 1998). These geochemical analyses revealed several anomalies sufficiently interesting to be considered as exploration targets. Moreover, the Lac Vernon area contains large-scale multi-element (Cu-Ni-U) anomalies, generating significant exploration interest (Labbé *et al.*, 1999). Recently, a few new exploration permits were acquired in the Lac Vernon area, following the discovery of an important Ni-Cu-Co-PGE showing (Qullinaaraaluk) in an ultramafic intrusion located in the area just south of our study area (Labbé *et al.*, 2000).

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REGIONAL GEOLOGY

The northeastern Superior Province, where the Lac Vernon area is located, is mainly composed of Neoarchean rocks with minor relics of Mesoarchean rocks that were reworked and assimilated during later tectono-magmatic events. These rocks are intruded by mafic dyke swarms and alkaline and carbonatite complexes. They are bounded to the north and west by Paleoproterozoic rocks of the Trans-Hudson Orogen and to the east, by the equivalent rocks of the New Québec Orogen (Labrador Trough). A Proterozoic deformation event overprints the Archean rocks in the vicinity of these orogens. The northeastern Superior is essentially composed of diverse plutonic rocks, with scattered remains of supracrustal rocks at different degrees of preservation. The regional structural trend of lithological assemblages, oriented NNW-SSE, marked by high-relief aeromagnetic anomalies, contrasts with the east-west alignment of major geological assemblages in the southern Superior Province (Card and Poulsen, 1998). In general, granitic and charnockitic plutonic complexes are associated with vast (40-100 km wide) positive aeromagnetic anomalies, whereas supracrustal rocks belts are commonly enclosed within tonalitic suites, characterized by weakly magnetic narrow (10-20 km) bands. The plutonic rocks essentially consist of tonalite, granodiorite, enderbite, diatexite and granite, with enclaves and intrusions of diorite, gabbro and pyroxenite-peridotite. These rocks are massive, foliated or gneissic. Volcano-sedimentary belts contain miscellaneous sequences of mafic volcanic rock, greywacke, iron formation, tuff, with minor amounts of felsic volcanic rock, sandstone, conglomerate, ultramafic rock and rare calc-silicate horizons. The different metamorphic assemblages observed in these supracrustal rocks indicate low pressure and high temperature metamorphic conditions, which correspond to the upper greenschist to the granulite facies (Bégin and Pattison, 1994; Percival and Skulski, 2000).

The main characteristics of the northeastern Superior Province are outlined in a geological and chronological framework (Percival *et al.*, 2001; Leclair *et al.*, 2001b ; Leclair *et al.*, 2001c). Structural and lithological correlations, combined with U/Pb geochronology data illustrate a complex geological history marked by a succession of magmatic and tectonic events that took place over a time frame of more than 300 million years. The northeastern Superior Province therefore appears to be the product of a succession of crustal growth episodes, followed by subsequent reworking episodes. The earliest geological elements are the remains of a Mesoarchean protocraton (3.1 - 2.9 Ga) identified by the presence of inherited and detrital zircons. These older terranes, difficult to identify, were largely recycled and obliterated by Neoarchean tectono-magmatic processes in the interval 2.89 - 2.66 Ga. However, the oldest mappable units consist of scattered bands of tholeiitic volcanic sequences enclosed in tonalites (2.88-2.87 Ga). A second episode of crustal growth is marked by the production of tholeiitic volcanic rocks and tonalite-trondhjemite suites bracketed between 2.84 and 2.80 Ga. An early phase of deformation (D_1), dated at 2.81 Ga, may be related to a tectonic accretion episode involving older terranes (Leclair *et al.*, 2001c). Subsequently, widespread magmatic activity took place in a diachronic fashion (2.79-2.74 Ga) with the emplacement of tonalite-trondhjemite and the production of both tholeiitic and calc-alkaline volcanic rocks. This event is also outlined by the presence of syenite and carbonatite. Later on, the appearance of granite, granodiorite and leucosome (2.735 and 2.725 Ga) marks the onset of potassic magmatism, generated by an episode of intracrustal melting, possibly due to the juxtaposition of different terranes (Leclair *et al.*, 2001c). In the wake of this potassic magmatism, significant volumes of enderbite, tonalite, granodiorite and tholeiitic and calc-alkaline volcanic rocks are produced (2.725 and 2.690 Ga). The effect of this prolonged intracrustal magmatism contributes to the onset of high-temperature metamorphism, responsible for the partial melting (2.698 and 2.675 Ga) and recycling of older lithologies. The presence of late- to post-tectonic zircon and monazite (2.68-2.62 Ga) is attributed to regional-scale hydrothermal activity. Finally, several fault networks channel late- to post-metamorphic hydrothermal activity (2.680-2.620 Ga), as well as syenite, carbonatite, diabase and lamprophyre intrusions.

Lithotectonic Subdivision

Subdivisions of the northeastern Superior Province into different lithotectonic domains were proposed by Percival *et al.* (1992; 1997b). About ten domains were identified based on aeromagnetic, lithological and structural criteria (Figure 1). Work by Percival *et al.* (1990, 1991) along the Rivière aux Feuilles led to a preliminary subdivision, which resulted in the definition of the "Tikkerutuk, Lac Minto, Goudalie and Utsalik" domains. Later studies to the north (Percival *et al.*, 1995b, 1996b, 1997b) helped constrain the "Inukjuak, Philpot, Qalluviartuuq, Lepelle and Douglas Harbour" domains. Subsequently, domain boundaries were extrapolated throughout the entire region, based solely on the extension of the various aeromagnetic anomalies. These domains may extend over several hundred kilometres, parallel to the northwest structural trend (Figure 1).

However, recent work carried out by the MRN has outlined several problems concerning boundaries and relationships between certain domains (Madore *et al.*, 1999;

Madore and Larbi, 2000; Gosselin and Simard, 2000; Parent *et al.*, 2000; Leclair *et al.*, 2001a; Simard *et al.*, 2001). Although each domain is characterized by typical lithologies, the absence of observable structural boundaries between the domains, and the distribution of some intrusive suites within several domains make the nature and contact zones of certain domains obscure and arbitrary. A regional study aimed at providing a better understanding of the main lithological and structural elements is underway, to review the lithotectonic subdivision of the northeastern Superior, and to place constraints on the regional geotectonic evolution.

Aeromagnetic and Lithostructural Characteristics of the Lac Vernon Area

The Lac Vernon area is characterized by the presence of five major aeromagnetic patterns that exhibit orientations varying from N-S to NW-SE. These patterns, labelled A to E on the aeromagnetic map (Figure 3), correspond to distinct lithological assemblages that will be described in greater detail in the following sections. Pattern A, oriented N-S, represents a positive aeromagnetic signature located in the western part of the map area. It is mainly associated with tonalites, granites and enderbites, and roughly corresponds to the "Tikkerutuk Domain" (Percival *et al.*, 1992). Pattern B forms a magnetic low, less than 20 km wide, arched towards the southeast. It mainly consists of tonalitic rocks, along with a narrow band of volcano-sedimentary rocks. Pattern C, located in the centre of the map area and about 40 km wide, is characterized by alternating narrow magnetic ridges and troughs. This striated magnetic pattern oriented NNW-SSE is truncated westward by a fault zone. It corresponds to a plutonic complex composed of diatexite, enderbite and granite, with bands of paragneiss. Further east, pattern D is marked by a magnetic low 10 to 15 km wide, associated with

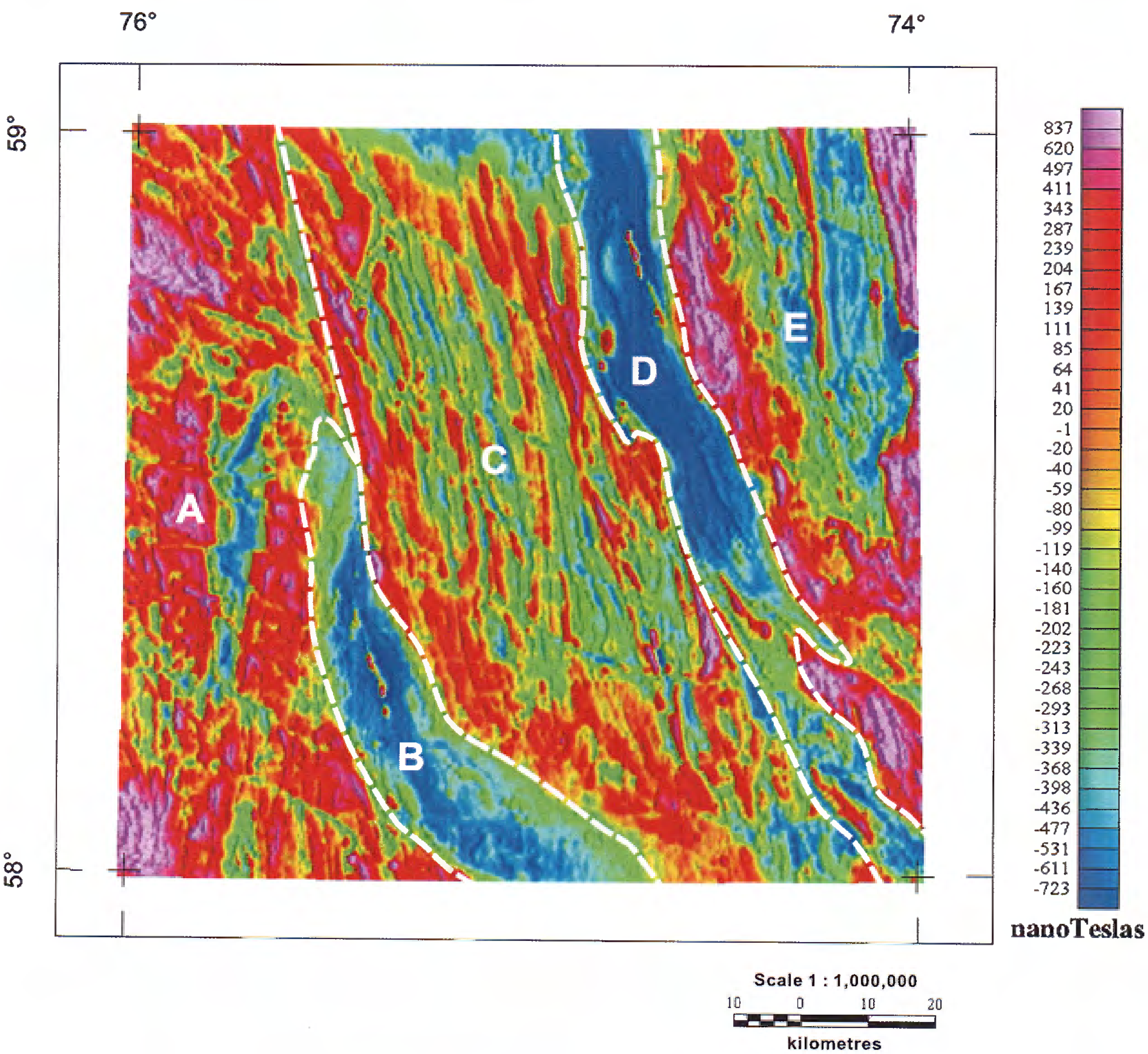


FIGURE 3 - Shaded total residual magnetic field map showing the boundaries of aeromagnetic patterns (A to E) in the Lac Vernon area (NTS sheet 34J). Aeromagnetic data taken from Dion and Lefebvre (1999).

bands of volcanic and sedimentary rocks enclosed in granodiorite and granite. Finally, the eastern part of the map area shows positive and negative aeromagnetic signatures oriented N-S to NNW-SSE (pattern E, Figure 3), related to a heterogeneous lithological assemblage including opdalites, charnockites, diatexites and granites, along with bands of mafic rocks and paragneisses.

STRATIGRAPHY

The Lac Vernon area is composed of Archean intrusive and volcano-sedimentary rocks intruded by Proterozoic diabase dykes. According to lithotectonic subdivisions proposed by Percival *et al.* (1992), these rocks essentially belong to the "Lac Minto Domain", with the exception of sectors to the west (Tikkerutuk Domain) and the northeast (Goudalie Domain) (Figure 1). However, this subdivision, which is the result of regional-scale extrapolation, does not allow to establish correlations between geological assemblages assigned to different domains. Subdivisions based on the notion of lithotectonic domain impose pre-established tectonic models without taking into account the stratigraphy. In this report, the notion of lithotectonic domain is used only to refer to previous work. However, we propose using a lithodemic subdivision based on notions of the North American Stratigraphic Code (MRN, 1986) applied, to the best of our ability, to metamorphic rocks. This subdivision is based on the lithological characteristics of different units, on cross-cutting relationships observed in the field, on petrography, radiometric ages and geochemical data. It helps establish a stratigraphy for supracrustal rocks and intrusive rocks, in addition to defining the geological framework of the Lac Vernon area. In order to simplify unit descriptions, the prefix "meta" was omitted, considering the fact that most of these rocks are metamorphosed to the amphibolite or granulite facies. The Lac Vernon area was subdivided into 10 Archean units (Figure 4). Paragneisses which could not be integrated to these lithodemic units were grouped into a single lithological unit without a stratigraphic connotation (M4a). Furthermore, two Proterozoic diabase dyke swarms were recognized in the area (not shown on the geological map). Type localities were identified for certain lithodemic units, in locations that provided sufficient information to characterize them adequately. A geochronology sample was collected at each of these type localities.

Paragneiss (M4a)

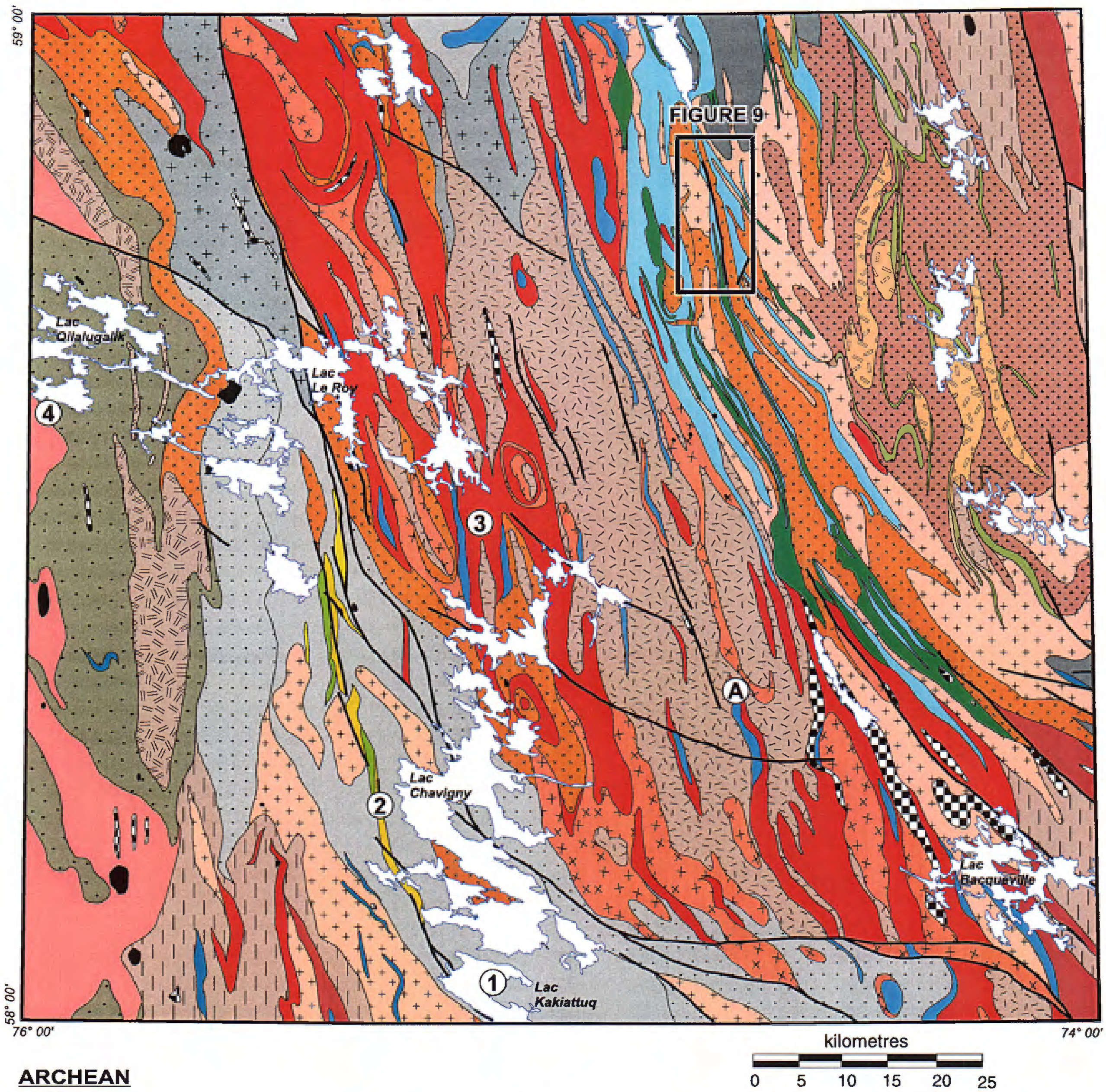
Lithological unit M4a incorporates all supracrustal rocks that could not be associated with one of the three complexes (Kogaluc, Chavigny and Le Roy) in the Lac Vernon area. This unit forms bands several kilometres long, mainly composed of paragneiss and a minor proportion of mafic gneiss. The main characteristic minerals observed in the paragneisses include garnet, biotite, sillimanite and more rarely cordierite, spinel and graphite. The paragneisses are commonly migmatized and may contain up to 40% material derived from partial melting. In several locations, they form impressive rusty zones tens of metres wide, visible from an aircraft. These zones are the result of the alteration of disseminated biotite, pyrite and pyrrhotite. They are frequently associated with silicate-facies iron formations composed of clinopyroxene, garnet, hornblende, grunerite, magnetite and quartz. In places, the paragneisses are also associated with mafic gneisses that exhibit compositional banding. This banding is characterized by alternating m-scale homogeneous mafic layers and cm-scale felsic to intermediate layers. The composition of the rocks and the alternating occurrence of these different bands suggests the mafic gneisses are volcanic in origin. Mafic layers are composed of hornblende, clinopyroxene and orthopyroxene. They frequently contain foliation-parallel orthopyroxene-bearing mobilizate. One to two-metre-thick quartz-rich bands are also observed; these may represent exhalative horizons. These bands regularly contain pyrite and pyrrhotite mineralization, either disseminated or in stringers. The presence of ultramafic rocks was noted in a few rare locations. Most rocks found in M4a paragneiss bands exhibit well-developed granoblastic textures.

Rochefort Suite (Arot)

The Rochefort Suite, introduced by Leclair *et al.* (2001a), groups all tonalitic rocks with green biotite, epidote and hornblende in the Lac La Potherie area (NTS 34I). These rocks were dated at 2769+6/-4 Ma (David, in preparation). Rocks of the Rochefort Suite outcrop in four zones, in the northern and eastern parts of the Lac Vernon area. The reader is referred to the work of Leclair *et al.* (2001a) for a detailed description of this suite.

Kogaluc Complex (Akog)

The Kogaluc-Tasiat belt, named by Percival *et al.* (1995a; 1995b), is located in the northeastern part of the map area (Figure 4). It consists of discontinuous bands of supracrustal rocks ranging from 1 to 8 km in thickness. These bands extend, one after the other, over a distance of 110 km along a NNW-SSE axis that corresponds to a negative aeromagnetic signature (pattern D, Figure 3). Supracrustal rocks are composed of variable proportions of mafic, intermediate and felsic volcanic rocks, pyroclastic rocks, sediments and iron formations. Rocks in the southern part are mainly composed of mafic and intermediate volcanic rocks, whereas the northern part consists of 80% sedimentary rocks such as greywackes, sandstones, siltstones and argillites (Percival



ARCHEAN

Qullinaaraaluk Suite (Aluk)
- Mafic and ultramafic rocks

Morrice Suite (Agdm)
- Granite

Lac Minto Suite (Amin)
- Enderbite
- Charnockite
- Opdalite
- Orthopyroxene-biotite diatexite

Le Roy Complex (Aroy)
- Granite
- Diatexite
- Heterogeneous enderbite
- Paragneiss

Qilalugalik Suite (Aqil)
- Heterogeneous enderbite
- Hornblende±clinopyroxene granite
- Hornblende-clinopyroxene tonalite

Chavigny Complex (Achy)
- Mafic volcanic rocks
- Felsic volcanic rocks and sedimentary rocks

Rivière-aux-Feuilles Suite (Arfe)
- Granodiorite

Bacqueville Suite (Abcv)
- Metamorphosed gabbroic rocks

Kakiattuq Suite (Akkk)
- Heterogeneous tonalite
- Granitized tonalite
- Homogeneous tonalite

Kogaluc Complex (Akog)
- Supracrustal rocks metamorphosed to the granulite facies
- Sedimentary rocks
- Undifferentiated volcanic rocks

Rochefort Suite (Arot)
- Tonalite

Paragneiss (M4a)

- Fault
- (3) Geochronology sample
- (A) Showings - Narsaaluk sector

FIGURE 4 - Simplified geology of the Lac Vernon area (NTS 34J).

et al., 1995a; Grosl, 1993). Rocks of the Kogaluc-Tasiat belt are enclosed within granodiorites of the Rivière-aux-Feuilles Suite (Arfe).

In order to maintain a coherent nomenclature for all volcano-sedimentary belts in the northeastern Superior Province, the supracrustal rocks of the Kogaluc-Tasiat belt are grouped in a new lithodemic unit known as the Kogaluc Complex (Akog). The Kogaluc Complex contains three informal units: undifferentiated volcanic rocks (Akog1), sedimentary rocks (Akog2) and supracrustal rocks metamorphosed to the granulite facies (Akog3). Since rocks of the Kogaluc Complex had already been mapped at 1:250,000 scale (Percival *et al.*, 1995b), fieldwork in the summer of 2000 was restricted to a few traverses in this sector. Consequently, the following lithological descriptions are based on work by the Geological Survey of Canada (Percival *et al.*, 1995a) and mining exploration companies such as Cominco, Soquem and Virginia Gold Mines (Grosl, 1993; Francoeur and Chapdelaine, 1994).

Undifferentiated Volcanic Rocks (Akog1)

Volcanic sequences in the Kogaluc Complex comprise strongly sheared mafic, intermediate and felsic rocks. These rocks form one to ten-metre thick horizons that could not be represented on the 1:250,000 scale geological map. Consequently, all these rocks were grouped into an undifferentiated volcanic rock unit (Akog1). Mafic rocks consist of mafic gneiss, amphibolite, basalt, mafic to intermediate tuff and fine-grained mafic schist. In certain locations, relics of pillowed basalt and gabbroic textures are well preserved (Percival *et al.*, 1995a; 1995b; Francoeur and Chapdelaine, 1994; Grosl, 1993). Mafic rocks generally exhibit a granoblastic texture, and show a dark green to grey-black colour in fresh surface. Intermediate rocks are composed of plagioclase-phyric andesite, pillowed andesite and sills of dioritic composition (Percival *et al.*, 1995a). Grosl (1993) reported the presence of brecciated and epidotized andesite in the southern part of the Kogaluc Complex. Felsic volcanic rocks consist of rhyolite, rhyolitic tuff and quartz-phyric rhyolitic tuff (Percival *et al.*, 1995a). The rock is light grey in fresh surface and weathers to a grey-white to brownish colour. Volcanic rocks of the Kogaluc Complex are characterized by a calc-alkaline geochemical signature (Skulski *et al.*, 1996). A sample of quartz porphyry rhyolite yielded a maximum age of 2759±1 Ma (Skulski *et al.*, 1996). The various volcanic lithologies are frequently interdigitated with sedimentary rocks such as iron formations, siltstones, greywackes, epiclastic rocks and pelites.

Sedimentary Rocks (Akog2)

The northern part of the Kogaluc Complex is dominated by the presence of sedimentary rocks, composed of biotite paragneiss, iron formation, sandstone, siltstone, quartzite, argillite and rare polygenic conglomerate (Grosl, 1993; Percival *et al.*, 1995a). Biotite paragneisses (metapelites) are composed of plagioclase (> 40%), quartz, biotite, muscovite, sillimanite and andalusite. They exhibit compositional banding marked by alternating mica-rich and garnet-rich layers. Siltstones, sandstones and quartzites occur as discontinuous horizons between 1 to 10 metres thick, generally intimately associated with iron formations (Grosl, 1993). Primary structures (laminations, cross-bedding and graded bedding) are preserved in less deformed bands. Conglomerates contain cm-scale clasts of sedimentary and volcanic rocks (Grosl, 1993). Iron formations are generally of the oxide facies, with the exception of a few sporadic and discontinuous silicate-facies horizons composed of garnet, grunerite, quartz and magnetite. Oxide-facies iron formations are banded, and consist of mm-scale to cm-scale layers of magnetite and quartz (Francoeur and Chapdelaine, 1994). A few of these appear to extend over more than 15 kilometres along strike, and range from 10 to 15 metres in thickness. They are associated with biotite schists, siliceous paragneisses and metagabbros. In certain locations, iron formations are altered and contain hornblende, chlorite, epidote, garnet and sulphides such as pyrrhotite, pyrite, arsenopyrite and chalcopyrite. They are banded and generally display a granoblastic texture.

Supracrustal Rocks Metamorphosed to the Granulite Facies (Akog 3)

Unit Akog3 is restricted to mafic gneiss (Akog3a) and paragneiss (Akog3b) bands found in the northeastern part of the map area (Figure 4). These remnants horizons form isolated bands less than one kilometre wide. Mafic gneisses are composed of orthopyroxene, clinopyroxene, hornblende, plagioclase, and rare garnet. Paragneisses contain garnet, biotite, plagioclase, quartz, sillimanite and rare cordierite. Garnet and sillimanite occur as mm-scale to cm-scale porphyroblasts. Silicate-facies iron formations, composed of garnet, grunerite, quartz and magnetite are also locally observed. All these rocks indicate metamorphic conditions corresponding to the upper amphibolite and granulite facies. This metamorphism may be related to the emplacement of opdalites of the Lac Minto Suite (Amin2), observed in the northeastern part of the area. The mafic gneisses are interpreted as volcanic rocks, based on their close association with paragneisses and iron formations (Percival *et al.*, 1995a; Grosl, 1993; Francoeur and Chapdelaine, 1994). Units Akog3a and Akog3b possibly represent high-grade metamorphic equivalents of volcanic and sedimentary rocks of the Kogaluc Complex (Akog1 and Akog2).

Kakiattuq Suite (Akkk)

The new lithodemic unit known as the Kakiattuq Suite (Akkk) was introduced in order to describe tonalitic rocks found in the Lac Chavigny and Lac Kakiattuq areas (Figure 4). These rocks coincide with a vast negative and uniform aeromagnetic signature located in the south-southwest part of the map area (pattern B; Figure 3). The Kakiattuq Suite is subdivided into three informal units: homogeneous tonalites (Akkk1), granitized tonalites (Akkk2), and heterogeneous tonalites (Akkk3).

Homogeneous Tonalite (Akkk1)

The type locality for the homogeneous tonalite unit (Akkk1) is located on an island on Lac Kakiattuq, at outcrop MP-00-1144 in the SIGÉOM database (UTM coordinates, NAD 83: 492894 E, 6434004 N). Field observations revealed the presence of two distinct mineral facies in the homogeneous tonalite unit, one containing biotite and the other biotite and hornblende. However, at 1:250,000 scale, these facies do not constitute mappable units. The homogeneous tonalite unit (Akkk1) therefore incorporates both mineral facies, and is treated as a single stratigraphic unit. A sample of biotite tonalite collected from the type locality yielded an age of 2740±4 Ma, interpreted as the age of emplacement for the tonalites (David, in preparation).

Homogeneous tonalites (Akkk1) are leucocratic and fine to medium-grained. They contain 5 to 15% biotite, hornblende and epidote. The tonalites exhibit a weakly to moderately developed foliation. Locally, a gneissosity is observed near ductile deformation zones. The rock is pale grey in fresh surface, with a whitish grey weathered surface. It contains rare enclaves of mafic gneiss. Granitic plutons and dykes intrude the tonalite. The petrographic characteristics of homogeneous tonalites of the Kakiattuq Suite are similar to those observed in the Rochefort Suite located further east (NTS sheet 34I, Leclair *et al.*, 2001a). However, there is a 25 Ma age difference between the Rochefort Suite (2769+6/-4 Ma; Leclair *et al.*, 2001a) and the Kakiattuq Suite (2740±4 Ma; David, in preparation), which suggests that the two suites represent two distinct magmatic events.

In thin section, the tonalite contains roughly equal proportions of quartz and plagioclase, with less than 10% K-feldspar. The latter phase is often interstitial, and occasionally occurs as isolated phenocrysts. The tonalite contains greenish biotite, epidote, titanite and rare hornblende. Accessory minerals include allanite, apatite, magnetite and zircon. A few samples contain secondary muscovite, which occurs in association with biotite, or sporadically on plagioclase crystals. Biotite sometimes occurs as poikilitic crystals with vermicular quartz globules. Automorphic to subautomorphic epidote crystals are superposed on plagioclase, biotite, hornblende and muscovite. Epidote grains may contain biotite and quartz inclusions. In certain locations, allanite occurs in the core of epidote crystals. On a macroscopic scale, the tonalites exhibit a well-developed foliation mainly defined by the alignment of biotite. In thin section, observed microfabrics reflect variable degrees of deformation. Less deformed rocks show a prefered orientation of micas, which wrap around large plagioclase crystals, as well as stretched quartz grains. In places, more intense deformation has led to the development of monocrystalline and polycrystalline quartz ribbons, as well as a granoblastic texture occurring along the margins of plagioclase grains which may also show bent and broken twins. The presence of green biotite and epidote indicates that the tonalites underwent lower-amphibolite-grade metamorphism (Turner, 1981). Moreover, several thin sections also exhibit retrograde assemblages with chlorite, pale green biotite (second generation), muscovite, epidote, as well as sericitized and saussuritized plagioclase.

Granitized Tonalite (Akkk2)

An important granitization phenomenon was observed along the margins of homogeneous tonalites (Akkk1), as well as in small isolated patches of tonalite. It is manifested by the presence of granitic material in diffuse contact with the tonalite, and by the irregular distribution of K-feldspar within the tonalite (Appendix 1; photo 1). Most of these K-feldspar crystals are interpreted as secondary crystals. In order to represent this granitization phenomenon, an informal unit of granitized tonalite (Akkk2) was defined in the Kakiattuq Suite. Note that characteristics such as grain size, mineralogy and composition (excluding the granitic material) of granitized tonalites (Akkk2) are similar to those of homogeneous tonalites (Akkk1). Consequently, it is possible that unit Akkk1 is the protolith of granitized tonalites. It is difficult to determine exactly when the K-feldspar was incorporated into the tonalite. In certain locations, fragmented and diffuse pink granitic injections are observed in the tonalites. The development of these injections is interpreted as being coeval with the emplacement of the tonalite, and therefore suggest syn-magmatic deformation. In other locations, the granitization process generates isolated cm-scale microcline phenocrysts as well as small interstitial K-feldspar crystals that enclose quartz and plagioclase crystals. In the latter case, the granitization is clearly secondary, and may be related either to important shear zones that bound the tonalites, or to the emplacement of younger granitic intrusions.

Heterogeneous Tonalite (Akkk3)

Unit Akkk3 consists of heterogeneous rocks characterized by a remarkable lithological and structural complexity at the scale of the outcrop. It is composed of tonalites strongly injected by and interdigitated with granodioritic and granitic material, in which a large amount of enclaves of paragneiss and mafic to intermediate gneiss, gabbronorite, ultramafic rocks and rare iron formation, are found. The main common mafic minerals present in the tonalite and granodiorite are biotite, hornblende, magnetite and locally, clinopyroxene. The foliation is generally well defined by the alignment of biotite, granitic phases and enclaves. However, in certain areas the foliation is undulating and more or less well developed. Granodioritic and granitic phases may contain 10 to 20% K-feldspar phenocrysts. Locally, dioritic phases are interdigitated with the tonalite. Enclaves of intermediate composition show compositional banding similar to thatwhich has been observed in supracrustal rocks. This banding is marked by alternating cm-scale hornblende-plagioclase and hornblende-clinopyroxene-plagioclase layers. In places, the enclaves are partially assimilated, yielding biotite-hornblende-magnetite schlieren. The presence of schlieren as well as granodioritic, granitic and dioritic phases within the tonalite gives outcrops a heterogeneous texture. We used the term "rainbow texture" to describe alternating bands of black, grey-pink, pink, dark grey and pale grey produced by the presence of these different lithologies.

It is quite likely that the granodioritic and the granitic materials in this unit reflect the migmatization of homogeneous tonalites (Akkk1) and granitized tonalites (Akkk2). It should be noted that there are similarities between rocks of the heterogeneous tonalite unit of the Kakiattuq Suite and those of the Sullupaugalik Suite (Parent *et al.*, 2000; Leclair *et al.*, 2001a; Berclaz *et al.*, 2001). The distribution of these two units however precludes the possibility of establishing correlations between the two suites at this time.

Bacqueville Suite (Abcv)

The Bacqueville Suite (Abcv) was established by Parent *et al.* (2000) to designate all dismembered dykes and bands of diorite and gabbro, including a minor amount of pyroxenite and lamproite (Percival and Card, 1994). These rocks are described as foliated to massive, homogeneous and medium to coarse-grained. They are found within most lithologies, and are cross-cut by granitic pegmatites. Leclair *et al.* (2001a) subdivided this suite into two informal units: a) gabbro-gabbronorite and b) quartz diorite. On the other hand, in the Lac Aigneau area (NTS 24E), Berclaz *et al.* (2001) interpreted the gabbros, diorites and gabbronorites as rocks associated with the MacMahon Suite. Consequently, they used the latter term to describe rocks that Parent *et al.* (2000) and Leclair *et al.* (2001a) had assigned to the Bacqueville Suite. In this report, we will use the term Bacqueville Suite to describe dioritic, gabbroic and ultramafic rocks that are foliated to gneissic, fine, medium or coarse-grained and generally granoblastic. Furthermore, we will exclude from the Bacqueville Suite late and undeformed gabbroic and ultramafic rocks. They latter are assigned to the new Qullinaaraaluk Suite (Aluk).

Metamorphosed Gabbroic Rocks (Abcv1)

The metamorphosed gabbroic rock unit (Abcv1) is mainly composed of gabbro, gabbronorite and locally, of ultramafic rocks. Gabbros and gabbronorites are mesocratic to melanocratic, whereas ultramafic rocks are melanocratic. Gabbros are composed of plagioclase, red biotite, hornblende, magnetite and rare clinopyroxene. However, the main mineral constituents in the gabbronorite are plagioclase, orthopyroxene, clinopyroxene, hornblende, red biotite and magnetite. In certain locations, the gabbro and gabbronorite may be somewhat leucocratic with only 15 to 30% mafic minerals. Accessory minerals include apatite, titanite, quartz and zircon. The rock takes on a dark green to greenish brown colour in weathered surface. The rock may contain magnetite-rich zones (> 70%), which gives it a dark rusty brown colour in weathered surface. Granoblastic textures are well developed, produced by the recrystallization of all mineral constituents including orthopyroxene, which has preserved some primary igneous features (Schiller texture). The foliation is defined by the alignment of biotite and mafic mineral trains. The biotite is superimposed on polygonized pyroxene and hornblende crystals. In places, the orthopyroxene is almost entirely replaced by its alteration products (talc, carbonate, chlorite, iddingsite, magnetite), and plagioclase may be sericitized and saussuritized. Elsewhere, olive green hornblende occurs as isolated grains and forms coronas around pyroxene grains. The hornblende may contain inclusions and relics of clinopyroxene and orthopyroxene. Coarse-grained mobilizate composed of plagioclase, orthopyroxene, clinopyroxene and biotite is frequently observed.

The gabbros and gabbronorites locally grade into ultramafic rocks, namely pyroxenite and peridotite. The pyroxenite is composed of clinopyroxene, orthopyroxene, hornblende, biotite, magnetite and minor plagioclase. In addition to these minerals, peridotite contains serpentinized olivine, spinel and talc. The deformation affecting these lithologies translates into the recrystallization of certain minerals into small polygonal grains and larger grains preferentially oriented to define the foliation. Rare sulphide-rich zones (pyrite and pyrrhotite) about 10 cm thick, occur within pyroxenites and the more mafic gabbroic phases.

Rivière-aux-Feuilles Suite (Arfe)

The Rivière-aux-Feuilles Suite, as defined in studies by the Geological Survey of Canada (Percival and Card, 1994; Stern *et al.*, 1994), essentially designated a mixed series of I-type calc-alkaline intrusions including pyroxene-hornblende granodiorites, tonalites, granites, diorites, gabbros-pyroxenites and synplutonic mafic dykes. The emplacement of the Rivière-aux-Feuilles Suite was established at *ca.* 2724 Ma, based on a few isotopic ages obtained from granodiorites (Machado *et al.*, 1989; Stern *et al.*, 1994). However, new geochronology data indicates that this series of plutonic rocks groups several intrusive events (Parent *et al.*, 2000; Berclaz *et al.*, 2001; Leclair *et al.*, 2001a; David, in preparation). Work conducted in the Lac Nedlouc area (NTS 34H) led Parent *et al.* (2000) to restrict the term "Rivière-aux-Feuilles Suite" to granodiorites and tonalites. Later on, mapping conducted in the Lac La Potherie area (NTS 34I) allowed Leclair *et al.* (2001a) to further constrain the nature of the Rivière-aux-Feuilles Suite, by excluding tonalitic rocks. In this report, the Rivière-aux-Feuilles Suite is therefore exclusively used to designate intrusive rocks with a granodioritic composition.

Granodiorites of the Rivière-aux-Feuilles Suite (Arfe) were observed in three locations in the Lac Vernon area: 1) in the northwestern part of the area, 2) in association with the Kogaluc Complex, and 3) along the western margin of the Le Roy Complex. The granodiorites form many intrusive bodies several kilometres in size, but without a distinctive magnetic signature. The rock is pale grey to pinkish grey in fresh surface and weathers to a pinkish white to pinkish grey colour. It is generally granodioritic in composition and medium-grained. Coarse-grained granitic phases occur in diffuse contact within the granodiorite. The latter contains 5 to 25% mafic minerals, namely biotite, hornblende, magnetite and rare epidote. Locally, the presence of muscovite and clinopyroxene is also noted. Accessory minerals include allanite, titanite, apatite and zircon. Dioritic enclaves, fine-grained and often granoblastic, are present within the Rivière-aux-Feuilles Suite. These enclaves are either aligned parallel to the foliation, or at an angle to the foliation. In several locations, mafic rock enclaves, and granitic and pegmatitic injections give the granodiorite a heterogeneous aspect. The alignment of biotite and certain granitic injections define an obvious foliation, but which becomes difficult to observe where the rock is homogeneous and massive.

Chavigny Complex (Achy)

The Chavigny Complex (Achy) constitutes a new lithodemic unit that designates volcano-sedimentary rocks located to the west and northwest of Lac Chavigny (Figure 4). These rocks form a continuous belt that extends for more than 30 km along strike, over a width of 1 to 2 km. This band is associated with a linear positive aeromagnetic signature oriented NNW-SSE. It occurs within a low magnetic zone which corresponds to tonalites of the Kakiattuq Suite (Akkk) (pattern B; Figure 3). The nature of the contact between the volcano-sedimentary rocks and the tonalites is poorly documented at this time. The Chavigny Complex is subdivided into two informal units: a) felsic volcanic rocks and sedimentary rocks (Achy1), and b) mafic volcanic rocks (Achy2).

Felsic Volcanic Rocks and Sedimentary Rocks (Achy1)

Rocks of the Chavigny Complex contrast with most assemblages occurring in known volcano-sedimentary complexes in the northeastern Superior Province. This distinction is based on the predominance of felsic volcanic rocks and the absence of ultramafic rocks. Nearly 70% of the Chavigny Complex consists of rocks with a rhyolitic to dacitic composition. A minor amount of sedimentary rocks is also present, generally occurring as discontinuous m-scale horizons. The main lithologies observed include rhyolite, rhyolitic tuff, sericite schist, greywacke, pelite, iron formation, polygenic conglomerate and anthophyllite-cordierite-biotite-phlogopite schist. These lithologies are grouped in unit Achy1, the felsic volcanic rock and sedimentary rock unit. Two type localities were selected to describe these lithologies: a) outcrop MP-00-1108 (Appendix 1; photo 2) in the SIGÉOM database (UTM coordinates, NAD 83: 479971 E, 6452682 N) for felsic volcanic rocks, and b) outcrop MP-00-1303 (UTM coordinates, NAD 83: 475545 E, 6475282 N) for polygenic conglomerates (Appendix 1; photo 3).

Felsic volcanic rocks occur as rhyolitic flows and rhyolitic to rhyodacitic tuffs. The tuffs exhibit cm-scale banding, marked by alternating felsic and intermediate layers and by variations in grain size and mafic mineral content (Appendix 1; photo 2). A few mm-scale mafic bands composed of biotite, hornblende and magnetite were also observed. At the type locality, a sample of rhyolite intercalated in a felsic tuff sequence yielded an age of 2722±4 Ma for the felsic volcanism in the Chavigny Complex (David, in preparation). The felsic volcanic rocks are generally leucocratic, with less than 10% mafic minerals, mostly composed of partially chloritized biotite. Rhyolitic flows are aphanitic or very fine-grained, bluish grey in fresh surface with a creamy white weathered surface. Felsic tuffs are roughly the same colour in fresh surface but with a slightly whiter weathered surface. A microscopic study of tuff samples revealed the presence of alternating bands composed, on the one hand, of small granoblastic quartz and plagioclase grains in an interstitial groundmass of plagioclase and sericite, and on the other hand, of aphanitic, cataclastic and sericitized material which contains quartz porphyroclasts. Cataclastic bands possibly reflect primary bedding enhanced by micro-shear zones. The strongly developed foliation is defined by the alignment of biotite or chlorite. Accessory minerals include apatite, zircon, epidote, pyrite, and rare rutile. Biotite is partially chloritized and replaced by chlorite. Epidote occurs as small xenomorphic patches and small euhedral crystals superimposed on chloritized biotite.

Schist units a few tens of metres wide are observed in several locations. These schists are interpreted as sheared equivalents of tuffs or rhyolitic flows. They have a whitish grey colour with a silver-green sheen. They are exclusively composed of quartz, plagioclase, sericite and muscovite. Locally, sericite and muscovite represent more than 30% of the volume of sheared rock. Quartz veins, either parallel to shearing or cross-cutting, are observed. A strong silicification is observed within and near the schists. Despite the presence of quartz veins and intense silicification, no trace of sulphides was detected. In these schistose layers, a crenulation cleavage overprints the mylonitic fabric, reflecting a deformation event that post-dates shearing.

Sedimentary rocks are distinguished from felsic volcanic rocks by the greater abundance of aluminous minerals such as biotite and garnet. They exhibit banding typical of greywackes, produced by alternating quartz-rich psammitic layers and biotite-garnet-rich pelitic layers. The penetrative foliation is better developed in the greywackes than in the volcanic rocks. Nevertheless, the greywackes are occasionally difficult to distinguish from felsic volcanic rocks, especially in the absence of garnet. Paragneisses exhibit granoblastic textures. In a few rare locations, oxide and silicate-facies iron formations less than ten metres wide are intercalated with the volcanic and sedimentary rocks.

Polygenic conglomerates were observed in the northern part of the Chavigny Complex. They form m-scale beds associated with garnet-bearing sedimentary rocks and felsic volcanic rocks. The conglomerates contain felsic volcanic rock, rusty sedimentary rock, iron formation and granitoid clasts (Appendix 1; photo 3). The conglomerates underwent significant stretching and flattening, since most clasts show 10:1:4 ratios. The presence of felsic volcanic clasts, whose age may be inferred from the age dating analysis of a rhyolite in the type locality (2722±4 Ma; David, in preparation) suggests a maximum age of 2722±4 Ma for conglomerate deposition.

A few bands of cordierite-anthophyllite-biotite-phlogopite schists having a thickness between one and ten metres extend for several kilometres along strike. These horizons occur at the interface between felsic and mafic volcanic rocks. The rock is bluish grey in fresh surface and weathers to a brown colour. These layers are frequently associated with siliceous horizons interpreted as exhalative beds. Pyrite and chalcopyrite were observed in the siliceous horizons. The presence of lead and zinc anomalies supports the interpretation that these layers reflect volcanogenic hydrothermal alteration (see section entitled "Economic Geology").

Mafic Volcanic Rocks (Achy2)

Mafic volcanic rocks (Achy2), which constitute about 20% of the total volume of the Chavigny Complex, occur in contact with felsic volcanic rocks, and more rarely so with sedimentary rocks. In a few locations, mafic rocks are associated with oxide and silicate-facies iron formation horizons about 10 metres thick. Geochemical data derived from mafic rock samples show compositions typical of tholeiitic basalts and andesitic basalts (see section entitled "Lithogeochemistry"). The presence of m-scale bands of cordierite-anthophyllite-biotite-phlogopite schist interpreted as volcanogenic hydrothermal alteration zones, suggests that the felsic and mafic volcanic rocks of the Chavigny Complex are coeval. The type locality selected for the mafic volcanic rock unit (Achy2) is located in the northern part of the Chavigny Complex, at outcrop JD-00-2296 (Appendix 1; photo 4) in the SIGÉOM database (UTM coordinates, NAD 83: 477520 E, 6474374 N). This outcrop shows mafic lavas, sometimes massive, and a minor felsic tuff component. The mafic lavas are characterized by the presence of plagioclase megacrysts reaching up to 3 cm. The size of phenocrysts decreases from east to west. The phenocrysts are stretched to a 10:1 ratio, forming well-developed subvertical lineations. In several locations, the mafic rocks are strongly sheared and form mafic schists. It is often quite difficult to ascertain the exact nature of the protolith, since primary textures have been obliterated by deformation and metamorphism.

In thin section, mafic volcanic rocks are composed of olive green hornblende, biotite, plagioclase, magnetite and minor quartz. They generally exhibit a granoblastic texture, with polygonized and occasionally zoned plagioclase crystals. The penetrative foliation is defined by the alignment of biotite and hornblende. Plagioclase is locally sericitized. Accessory minerals include epidote, titanite, apatite, zircon and sulphides. Locally, hornblende is partially retrograded to chlorite and epidote, suggesting that rocks of the Chavigny Complex underwent greenschist-facies retrograde metamorphism.

Qilalugalik Suite (Aqil)

The western part of the area is characterized by the presence of rocks assigned to the "Tikkerutuk Domain" defined by Percival *et al.* (1992). This domain corresponds to a vast irregular positive aeromagnetic signature oriented north-south (Figure 3; pattern A), ranging from 50 to 100 km in width. Further south, the presence of similar lithologies and magnetic signatures suggests a continuity between the "Tikkerutuk Domain" and the Bienville Subprovince (Hocq, 1994; Skulski *et al.*, 1998). Based on geochronology data, the "Tikkerutuk Domain" consists of granitoids bracketed between 2686 and 2710 Ma (Skulski *et al.*, 1998; Percival *et al.*, 2001; Parent *et al.*, 2000). The Qilalugalik Suite takes into account the appearance of new lithologies that coincide with a change in magnetic signature. This suite comprises three units: a) hornblende-clinopyroxene tonalites (Aqil1), b) hornblende±clinopyroxene granites (Aqil2), and c) heterogeneous enderbites (Aqil3).

Hornblende-Clinopyroxene Tonalite (Aqil1)

A single type locality was defined for the Qilalugalik Suite, and it represents the hornblende-clinopyroxene tonalite unit (Aqil1). This type locality is situated near Lac Qilalugalik, at outcrop MP-00-1290 in the SIGÉOM database (UTM coordinates, NAD 83: 442505 E, 6500828 N). A sample collected from this outcrop yielded ages of 2709±3 Ma and 2780±8 Ma, respectively interpreted as the age of emplacement of the tonalite, and an inherited age from an older lithology (David, in preparation). The composition ranges from tonalitic to granodioritic, but most thin sections and stained samples reveal a tonalitic composition. The purplish colour, typical of this unit, is caused by the burgundy colour of plagioclase. Another significant characteristic of the Qilalugalik Suite is the presence of clinopyroxene and hornblende. The tonalites are leucocratic, weakly foliated and medium-grained. They contain 5 to 15% enclaves of fine-grained diorite (clinopyroxene, hornblende, biotite), mafic rock (orthopyroxene, clinopyroxene ± hornblende) and migmatitic paragneiss, between 10 cm and 1 m in size. In certain locations, bands of mafic gneiss and paragneiss from 10 m to 1 km in size are relatively well preserved. The heterogeneous aspect of outcrops is due to the presence of coarse-grained orange-pink diffuse granitic phases that contrast with the purplish medium-grained tonalite. The rock locally contains K-feldspar phenocrysts up to 3 cm long. Leucocratic massive granitic veins and dykes intrude the tonalite.

In thin section, the tonalite contains coarse plagioclase crystals surrounded by small recrystallized quartz grains. Plagioclase grain boundaries are strongly saussuritized. The tonalite contains 5 to 15% mafic minerals, mainly composed of hornblende, clinopyroxene, brown biotite and epidote, with accessory minerals such as titanite, magnetite, apatite, zircon and leucoxene. Clinopyroxene and biotite are respectively transformed into hornblende and chlorite. In several locations, only relics of clinopyroxene crystals are observed, whereas the hornblende occurs as perfectly automorphic crystals that contain quartz and apatite inclusions. The foliation is defined by a weak alignment of chloritized biotite, and by quartz ribbons. Epidote occurs as euhedral to subhedral crystals that superimpose sericitized plagioclase and chlorite. It generally occurs closely associated with chlorite and more rarely with carbonates. A petrographic study reveals that the commonly greenish tinge of the rock is caused by the presence of chlorite.

Hornblende ± Clinopyroxene Granite (Aqil2)

The granitic unit of the Qilalugalik Suite (Aqil2) occurs along the southern and northern extensions of unit Aqil1 (Figure 4). The rock is granitic in composition, has a purplish colour and contains hornblende, clinopyroxene and burgundy plagioclase. Apart from the relative proportions of quartz, plagioclase and microcline which are different, rocks in the granitic unit (Aqil2) show mineral and textural features identical to those of the tonalitic unit (Aqil1). In places, the presence of K-feldspar and burgundy plagioclase phenocrysts reaching up to 4 cm in size is noted. These phenocrysts are commonly surrounded by a mm-scale whitish rim. Phenocrysts are sometimes resorbed, corroded and rounded. The foliation is generally well defined by mafic mineral aggregates as well as by quartz ribbons, and by the alignment of phenocrysts.

Heterogeneous Enderbite (Aqil3)

Unit Aqil3 consists of enderbite with a heterogeneous aspect. In addition to its great heterogeneity, this unit is characterized by the abundance of dioritic enclaves and the presence of granodioritic and tonalitic phases. The enderbite forms km-scale intrusions bordering Aqil1 tonalites as well as bodies generally less than 100 metres wide enclosed within the latter. With the exception of enclaves, the rock is generally leucocratic and medium-grained. It has a golden brown colour, typical of charnockitic intrusions. In places, burgundy plagioclase and a purplish tinge similar to those observed in units Aqil1 and Aqil2 are noted. The foliation is well defined by the alignment of biotite, enclaves and granodioritic phases. The near-complete assimilation of enclaves is indicated by the presence of schlieren composed of mafic minerals and mafic gneiss restites. Paragneiss enclaves and bands are also observed in the enderbite. Locally, granodioritic and tonalitic phases become the major components in outcrop. Late pegmatite veins clearly crosscut the heterogeneous enderbite.

In thin section, the enderbite contains less than 10% mafic minerals, composed of orthopyroxene, clinopyroxene, magnetite and lesser proportions of red biotite. Orthopyroxene occurs as fractured euhedral to subhedral crystals with a yellowish alteration consisting of talc, carbonate, chlorite, iddingsite and magnetite. Orthopyroxene is occasionally surrounded by a thin hornblende rim, as opposed to clinopyroxene, whose grain boundaries often show evidence of retrogression by chlorite replacement. Accessory minerals include hornblende, chlorite, apatite, epidote and zircon. A weak foliation is defined by the alignment of biotite, pyroxene trains and elongated quartz grains. Locally, incipient quartz grain subdivisions and polygonization of plagioclase and pyroxene grains is observed.

Le Roy Complex (Aroy)

The central part of the map area is characterized by a prominent linear magnetic signature. It features alternating positive and negative aeromagnetic anomalies oriented NNW-SSE (pattern C, Figure 3). This signature reflects a lithological diversity and complexity, expressed by alternating diatexite, paragneiss, granite and enderbite units. Field observations outline gradual and transitional contacts between paragneiss, migmatitic paragneiss, diatexite and granite. Furthermore, the emplacement of enderbites was likely accompanied by an increase in the geothermal gradient, sufficient to induce partial melting in paragneisses and generate diatexites and granites. Since all these lithologies appear to be associated, we have grouped them into a single lithodemic unit known as the Le Roy Complex, comprising four informal units: paragneisses (Aroy1), enderbites (Aroy2), diatexites (Aroy3) and granites (Aroy4).

Paragneiss (Aroy1)

Paragneisses (Aroy1) in the Le Roy Complex occur as m-scale to km-scale thick bands reaching up to 10 kilometres in length. They are distinguished from paragneisses of the Kogaluc Complex (Akog2) by the absence of associated volcanic rocks and by a greater abundance of granitic material resulting from partial melting. The paragneiss unit (Aroy1) incorporates all migmatized sedimentary rocks that contain less than 50% mobilizate. The paragneisses are generally grey-brown to rusty brown. They are composed of plagioclase, quartz, red biotite, garnet, cordierite, sillimanite, magnetite and locally andalusite. Accessory minerals include zircon, epidote, and rarely spinel. The paragneisses are commonly fine-grained and exhibit a granoblastic texture. The foliation is defined by the alignment of biotite and oriented inclusions of sillimanite, biotite, quartz and plagioclase enclosed in porphyroblastic garnet. Sillimanite is abundant in intense deformation zones. Cordierite-biotite-sillimanite-garnet assemblages indicate that the paragneisses underwent upper amphibolite grade metamorphism. In a few rare locations, orthopyroxene is present, indicating that certain parts of this unit reached the granulite facies. Granitic to locally tonalitic leucosomes are composed of quartz, plagioclase, microcline, cordierite, garnet, sillimanite, spinel and andalusite. They form a migmatitic layering parallel to the foliation. Since these leucosomes possess characteristics similar to those described in diatexites of unit Aroy3, the reader is referred to the description of this unit.

Heterogeneous Enderbite (Aroy2)

Unit Aroy2 is composed of heterogeneous enderbitic intrusions. The heterogeneous nature of the enderbite is marked by the presence of 10 to 20% coarse-grained opdalitic mobilizate, and 20 to 50% medium-grained granodioritic material. No sharp contacts are observed between the enderbite, the opdalitic mobilizate and the granodioritic phases. This heterogeneity is locally enhanced by the presence of mafic to intermediate enclaves composed of clinopyroxene, orthopyroxene, hornblende and biotite. These enclaves are partially assimilated and stretched parallel to the foliation. The presence of mafic enclave relics, of fine-grained dioritic layers and of coarse-grained mobilizate injected parallel to the foliation give the rock a diatexitic texture.

The fresh enderbite is brown-green and it weathers to a golden brown colour. It is characterized by the presence of orthopyroxene and red biotite. Granodiorite phases contain red biotite and occasionally orthopyroxene in the vicinity of mafic enclaves, suggesting that a metasomatic process took place between the magma and enclaves. The sporadic distribution of orthopyroxene and the presence of diffuse granodioritic phases in the enderbite may be explained, in part, by the addition of H_2O and CO_2 in the magma. Assimilation of Aroy1 paragneisses constitutes a source of hydrated material which may explain an increase in the volatile content, and lead to the breakdown of orthopyroxene. Heterogeneous enderbites, as well as their granodioritic phases, are clearly cross-cut by veins and bodies of leucocratic and hololeucocratic granite assigned to unit Aroy4.

Diatexite (Aroy3)

The term diatexite is used here, in accordance with the definition of Brown (1973), to designate migmatitic rocks in which the proportion of material derived from partial melting exceeds 50% of the volume of the rock. Diatexites are therefore migmatites formed by a high degree of partial melting, which generated significant volumes of granodioritic to tonalitic intrusive rocks. Diatexites are characterized by an inequigranular texture, textural and compositional heterogeneity at a macroscopic scale, and by the development of flow structures that obliterate pre-migmatization structures (Sawyer, 1986; Sawyer and Barnes, 1988).

Unit Aroy3 is composed of cordierite-garnet-sillimanite diatexite (Appendix 1; photo 5); its type locality is situated near Lac Le Roy (Figure 4), at outcrop AL-00-023 in the SIGÉOM database (UTM coordinates, NAD 83: 491006 E, 6483933 N). A sample of relatively homogeneous diatexite, from which biotite schlieren were removed in the sampling process, yielded an age of 2698±1 Ma, interpreted as the age of emplacement for the diatexite (David, in preparation). Furthermore, an age of 2731±13 Ma possibly reflects an inherited age from an older lithology (David, in preparation).

Diatexites of the Le Roy Complex (Aroy3) form bodies several kilometres in size, elongated along the dominant NW-SE structural trend. These bodies contain bands from one to ten metres wide of garnet-biotite-sillimanite-cordierite paragneisses (Aroy1). The diatexites may be stratigraphically and tectonically associated with the granites and the paragneisses. It is difficult to establish boundaries between these units since their contacts are gradual. The diatexite is yellowish grey, and takes on a rusty brown tinge when the biotite content increases. The grain size, texture and composition vary considerably at a macroscopic scale. Relative proportions of plagioclase, K-feldspar and quartz are also variable, and yield a monzogranitic to locally tonalitic composition. The grain size ranges from coarse to medium over a few centimetres, giving the diatexite a typical inequigranular texture. This texture, combined with the presence of mm-scale biotite schlieren, gives the rock a heterogeneous, disorganized and poorly crystallized aspect.

In thin section, microcline and plagioclase grains respectively may be microperthitic and antiperthitic, which suggests that the diatexite is derived from the crystallization of a liquid rather than solid-state metamorphic recrystallization. Quartz occurs as large patches. The characteristic minerals are red-brown biotite, garnet, cordierite, sillimanite, magnetite and rarely andalusite and spinel. Garnet is porphyroblastic and poikilitic, with inclusions of sillimanite, biotite, magnetite and rarely plagioclase. Andalusite occurs as cm-scale crystals, and small crystal relics isolated by fibrolite. Accessory minerals include zircon, rutile, titanite and sulphides. The presence of chlorite, sericite, muscovite, epidote and carbonate indicates late alteration. Deformation ranges from weak to intense. As the degree of deformation increases, so does the alignment of biotite-garnet schlieren. The schlieren seem associated with a reduction in the grain size of quartz and plagioclase (mortar texture), indicating that part of the deformation is solid state or subsolidus. The foliation wraps around large plagioclase crystals and garnet porphyroblasts, and is also defined by the presence of polycrystalline quartz ribbons, and trains of spinel grains.

Granite (Aroy4)

Granites genetically linked to diatexites (Aroy3) of the Le Roy Complex are assigned to informal unit Aroy4. These granites occur in transitional contact with diatexites. The granite is pale pink in weathered surface, and red-pink in fresh surface. It is leucocratic to hololeucocratic, and massive to foliated. Characteristic minerals are biotite, magnetite, epidote, and more rarely, hornblende and clinopyroxene. Garnet is absent, except where diatexites and paragneisses are locally present in the granite. Accessory minerals include titanite, zircon and apatite. Locally, biotite-magnetite pods form mm-scale schlieren. The rock is medium to coarse-grained. It contains granitic or granodioritic pegmatitic phases, as well as K-feldspar phenocrysts. The granite contains a variable amount of diorite, tonalite, mafic gneiss and paragneiss enclaves. The foliation is defined by the alignment of biotite, pegmatitic phases and stretched enclaves. Quartz crystals are occasionally stretched.

Lac Minto Suite (Amin)

Work by Percival *et al.* (1990, 1991) and Percival and Card (1994) revealed the presence of vast expanses of orthopyroxene-biotite diatexite in the Lac Minto area (NTS 34G) and the Rivière aux Feuilles area (NTS 34H), considered to be one of the main characteristics of the "Lac Minto Domain". In order to establish a regional stratigraphic framework, Parent *et al.* (2000) introduced a lithodemic unit known as the Lac Minto Suite, to designate orthopyroxene-biotite diatexites. Subsequently, surveys conducted in the Lac La Potherie area (NTS 34I) led to a modification in the description of the Lac Minto Suite, in order to include charnockitic-type rocks (Leclair *et al.*, 2001a). A U/Pb zircon age of 2713±2 Ma was obtained from a diatexite located in the Lac Minto area, and interpreted as the age of crystallization of the diatexite (Percival *et al.*, 1992; Percival and Card, 1994). However, ages of 2700±1 Ma and 2698±1 Ma were also respectively obtained from zircons and monazites in the same diatexite. Based on these fragmental results, it is currently impossible to precisely establish the age of crystallization of the diatexite. The lithodemic unit of the Lac Minto Suite, identified in the Lac Vernon area, is subdivided into four informal units: diatexites (Amin1), opdalites (Amin2), charnockites (Amin3) and enderbites (Amin5).

Orthopyroxene-Biotite Diatexite (Amin1)

The orthopyroxene-biotite diatexite (Amin1) is restricted to three small units located in the southwestern, southeastern and northeastern parts of the Lac Vernon area (Figure 4). A distinctive characteristic of these diatexites is their heterogeneity, due to compositional and textural variations observed in the rock. The composition ranges from granitic to locally tonalitic. However, observed textural variations are similar to those described in diatexites of the Le Roy Complex (Aroy3). The different assemblages observed in diatexites of the Minto Suite are: orthopyroxene-biotite, orthopyroxene-biotite-clinopyroxene, orthopyroxene-biotite-garnet, and orthopyroxene-biotite-garnet-clinopyroxene. The diatexites may also contain magnetite and locally hornblende, with zircon and apatite as accessory minerals. They contain enclaves and bands of granoblastic paragneiss with or without garnet, enclaves of granoblastic diorite and rare enclaves of medium-grained gabbronorite. The diatexites are commonly intruded by leucocratic granite veins and dykes.

Opdalite (Amin2)

The opdalite unit (Amin2) constitutes a large body located east of the Kogaluc Complex (Figure 4). Opdalite outcrops are free of enclaves, with the exception of a few outcrops found near the contact with diatexites, where up to 25% dioritic and paragneissic enclaves are observed. The rock weathers to a light grey-brown colour, and its fresh surface is grey-brown, with a commonly greenish tinge due to the plagioclase. Mafic minerals (10 to 40% of the rock) include biotite, orthopyroxene, clinopyroxene, magnetite, and rarely hornblende. The foliation, generally fairly well developed, is defined by the alignment of biotite and orthopyroxene. The biotite is reddish brown, whereas the hornblende is green. Along major deformation zones, orthopyroxene grain margins are replaced by talc, carbonate, iddingsite and chlorite. In certain cases, orthopyroxene is replaced by its alteration products. The opdalite locally grades into an enderbite or a charnockite with K-feldspar phenocrysts reaching up to 1.5 cm long. In places, medium-grained granitic phases occur as injections, or in gradual contact with the opdalite.

Charnockite (Amin3)

The charnockite unit (Amin3) occurs east of the Kogaluc Complex in km-scale bodies within the opdalite unit. It is foliated and typically displays a coarse-grained igneous texture. It is very magnetic and leucocratic, with 10 to 20% mafic minerals such as orthopyroxene, clinopyroxene, hornblende, biotite and magnetite. The greenish brown colour in fresh surface, due to the colour of plagioclase, is typical of charnockitic rocks. Overall, the charnockite is fairly heterogeneous in terms of both texture and proportion of enclaves. It may contain up to 20% enclaves of biotite±garnet±orthopyroxene paragneiss and biotite-garnet-sillimanite±spinel paragneiss, with rare dioritic enclaves. The coarse to medium grain size gives the rock an inequigranular texture. The presence of K-feldspar phenocrysts from 1 to 3 cm long, and a few orthopyroxene grains up to 1 cm long give the rock a porphyritic aspect in many locations. The alignment of biotite defines a foliation, which is locally enhanced by the presence of biotite schlieren. The preferential orientation of phenocrysts parallel to the foliation may suggest syn- to late-tectonic emplacement relative to the regional deformation. In several locations, a K-feldspar-phyric granitic phase, with or without orthopyroxene, occurs as *in situ* mobilizate and as injections in the charnockite. Its presence may indicate a local transformation of the charnockite into granite.

Enderbite (Amin5)

Unit Amin5 is composed of rocks with a heterogeneous aspect, since outcrops contain enderbite, charnockite and 5 to 25% mafic enclaves. The heterogeneity observed at first glance may be explained by the presence of injections of coarse-grained charnockitic material with diffuse contacts within the enderbite (Appendix 1; photo 6). The enderbite is homogeneous, leucocratic and medium to coarse-grained, but may occasionally exhibit heterogeneous textures similar to those described in diatexites. Phenocrysts of K-feldspar, plagioclase and orthopyroxene are present in the charnockitic material. Diffuse contacts between the enderbite and the charnockitic material suggest the two phases are coeval and derived from the same magma. The charnockitic material is believed to correspond to a more fractionated phase, mixed with the enderbite before the latter was fully crystallized. The foliation is undulating and difficult to measure. Most outcrops in this unit contain 10-cm size enclaves of commonly granoblastic hornblende-clinopyroxene diorite, foliated mafic gneiss and rarely migmatized paragneiss. These enclaves are aligned parallel to the foliation. Local biotite schlieren possibly represent the remains of completely assimilated paragneiss enclaves. Late injections of orthopyroxene-free granitic material occurring as dykes and veins, cross-cut both enderbites and charnockites.

Morrice Suite (Agdm)

The Morrice Suite is a lithodemic unit that was originally defined in the Nedlouc area (Parent *et al.*, 2000) to describe granitic intrusions constrained by and associated with a weak or neutral magnetic signature. These authors suggest that granites of the Morrice Suite and diatexites of the Rivière-aux-Mélèzes Suite have a common source, where the granites represent a magma derived either from a greater degree of partial melting or from the crystallization of a more fractionated liquid. Later on, Leclair *et al.* (2001a) modified the description of the Morrice Suite to include only granites for which no genetic link could be established with other lithologies.

In the Lac Vernon area, the latter approach was followed to describe scattered granitic intrusions without any distinctive characteristics. This approach excludes granites associated with diatexites of the Le Roy Complex (Aroy4) and hornblende-clinopyroxene granites of the Qilalugalik Suite (Aqil2). Rock of the Morrice Suite show a granitic composition, but locally contain granodioritic phases. The granite is grey-pink in fresh surface, with a pink-red weathered surface. It is leucocratic to hololeucocratic, and contains 2 to 15% mafic minerals. The main mafic minerals are biotite and hornblende, with rare clinopyroxene. K-feldspar phenocrysts are frequently observed. The granite contains enclaves of quartz diorite, mafic gneiss, foliated tonalite, garnet paragneiss and diatexite. The rock is massive to weakly foliated. The foliation is often undulating, difficult to measure, and rarely defined by the alignment of diorite enclaves.

Qullinaaraaluk Suite (Aluk)

The Qullinaaraaluk Suite was introduced to designate undeformed mafic to ultramafic intrusive rocks. These rocks had been described by Parent *et al.* (2000) and by Leclair *et al.* (2001a) as units of the Bacqueville Suite. Mapping conducted in the Lac Vernon area enabled us to distinguish late mafic and ultramafic rocks from the Bacqueville Suite. The type locality for this unit is found 10 kilometres north of Lac Qullinaaraaluk (not shown; see Labbé *et al.*, 2000), at outcrop JD-00-2236 (NTS 34G) in the SIGÉOM database (UTM coordinates, NAD 83, zone 18: 518705 E, 6393327 N). This is also the discovery outcrop for the Qullinaaraaluk Ni-Cu-Co showing.

Mafic to Ultramafic Intrusions (Aluk)

Unit Aluk consists of late intrusions composed of mafic and ultramafic phases forming bodies rarely exceeding one kilometre in diameter. Consequently, many of these intrusions are not shown on the geological map. Rocks of the Qullinaaraaluk Suite intrude all Archean lithologies in the map area. They clearly cross-cut the regional foliation, and do not appear to have been affected by metamorphism and deformation. In certain areas, the long axis of mafic intrusions is at an angle relative to the structural trend, suggesting these intrusions are most likely post-tectonic (Labbé *et al.*, 2000).

Mafic rocks consist of homogeneous, massive and medium-grained leucogabbro to mesogabbro. The rock has a bluish tinge in fresh surface, whereas weathered surfaces are brown and crumbly. Ultramafic intrusions are composed of pyroxenite, olivine pyroxenite, hornblendite and locally peridotite. They are homogeneous, fine to coarse-grained, massive and locally brecciated with coeval injections of pegmatitic tonalite (Appendix 2; photo 3). The rock is dark green. In thin section, pyroxenites are composed of clinopyroxene, orthopyroxene, biotite and rare interstitial plagioclase crystals. The olivine pyroxenite consists of large and small grains of orthopyroxene, clinopyroxene and olivine (< 40%), and a few interstitial plagioclase grains. The peridotite contains more than 40% olivine crystals, set in a groundmass largely composed of clinopyroxene. A minor amount of magnetite is generally associated with the olivine. In all three cases, the rock exhibits primary textures. Large hornblende crystals may contain pyroxene and olivine inclusions. Clinopyroxene shows no evidence of retrogression, whereas orthopyroxene is partially transformed into a yellowish alteration product composed of talc, carbonate and iddingsite. Olivine occurs as sub-rounded grains and inclusions in pyroxene grains. It is generally well preserved, occasionally cracked, with only traces of iddingsite alteration. Overall, the ultramafic rocks contain 1 to 5% disseminated pyrrhotite and traces of apatite.

Diabase Dykes

Rocks in the area are intruded by post-orogenic diabase dykes. These dykes, less than 30 m thick, occur as rectilinear discontinuous bodies non-mappable at 1:250,000 scale. The chilled margins of the dykes are locally affected by late fractures. The massive rock is characterized by an ophitic to subophitic texture, and a fine to coarse grain size. It is generally fresh, with a typically greenish brown weathered surface. According to paleomagnetic and geochronology studies by Buchan *et al.* (1998) in the Rivière aux Feuilles sector, these dykes may belong to the Maguire (*ca.* 2230 Ma) and Minto (1998±2 Ma) swarms. Only about twenty diabase dykes were inventoried in the entire map area. The most abundant dykes are oriented WNW-ESE, between 95 and 130°. Their orientation is comparable to that of Maguire dykes. The remaining dykes are generally oriented NW-SE, between 320 and 345°, and may belong to the Minto swarm.

STRUCTURE

Regional Setting

The Lac Vernon area, much like the rest of the northeastern Superior Province, shows a regional structural trend broadly oriented NNW-SSE, illustrated by the numerous high-relief aeromagnetic anomalies (positive and negative). Overall, this area is characterized by five major aeromagnetic patterns (see section entitled "Aeromagnetic and Lithostructural Characteristics of the Lac Vernon Area"; Figure 3) corresponding to distinct lithological assemblages. These patterns range from a NW-SE to a N-S orientation. The aeromagnetic trend that characterizes each pattern makes it possible to identify major structural discontinuities, clearly visible at a regional scale. These structural discontinuities take on a roughly sigmoidal shape. Consequently, they may be related to a regional transpression-driven deformation system (Leclair, 2001). Variations in the orientation of the regional foliation outline five structural domains (Figure 5), each roughly corresponding to one of the five magnetic patterns (Figure 3). The results of a structural analysis of the regional foliation, fold axes, lineations and cross-cutting relationships between the different planar structures outline a complex structural setting. It is interpreted to be the result of at least six episodes of polyphase deformation, coeval with the emplacement of voluminous plutonic bodies during the period bracketed between 2810 and 2680 Ma (Leclair *et al.*, 2001a; Leclair *et al.*, 2001b; Parent *et al.*, 2000). Overall, the structure in the area is represented by a dominant foliation affected by episodes of complex folding and shearing, as well as late brittle deformation. The outcrop pattern of lithological units is also shaped by syn- to late tectonic intrusive events, that control or modify the overall structural trend. This suggests that the structural evolution of the Lac Vernon area involved a combination of stresses related to tectonic and magmatic phenomena. However, more detailed studies are needed to assess the influence of each of these phenomena in the regional deformation.

Rocks in the Lac Vernon area reflect a complex structural and tectono-magmatic evolution, involving two phases of ductile and folding deformation, one phase of intense shearing and one late phase of brittle deformation. This structural scheme may be broadly correlated with those already proposed for the Lac Nedlouc (Parent *et al.*, 2000) and Lac La Potherie (Leclair *et al.*, 2001a) areas. In these two areas, five phases of ductile and folding deformation (D_1-D_5) and one phase of brittle deformation (D_6) were documented. The first phase of deformation D_1 is marked by the presence of a pre-D_2 fabric mainly observed in the Vizien belt (Lin *et al.*, 1995; 1996). Phase of deformation D_2 is expressed by the presence of the dominant penetrative foliation oriented parallel to lithological contacts (NNW-SSE), as well as isoclinal folds. This foliation is affected by tight to isoclinal F_3 folds, m-scale to km-scale wave length and oriented WNW-ESE to NNE-SSW. Phase of deformation D_4 is associated with shear zones oriented NW-SE. Structures associated with phase D_5 correspond to open E-W folds locally observed in volcano-sedimentary sequences. Phase D_6 is responsible for the formation of a network of late brittle faults with important cataclastic and pseudotachylitic zones and associated hematitization and epidotization.

Structural Elements and Deformation

Volcanic and sedimentary structures and textures were identified in a few locations in the better preserved supracrustal rocks of the Lac Vernon area. They most likely represent the remains of primary bedding (S_0), albeit transposed by deformation and largely obliterated by metamorphic recrystallization. In a few rare locations in sedimentary rocks, primary bedding, graded bedding and cross-bedding are observed. In volcanic rocks, chilled margins in flattened pillows, pyroclastic horizons and amygdaloidal lavas are observed. Moreover, compositional banding observed in more strongly deformed rocks probably represents primary sedimentary bedding that has been modified and enhanced by tectono-metamorphic processes. At the scale of the map however, the scarcity of primary structures and textures

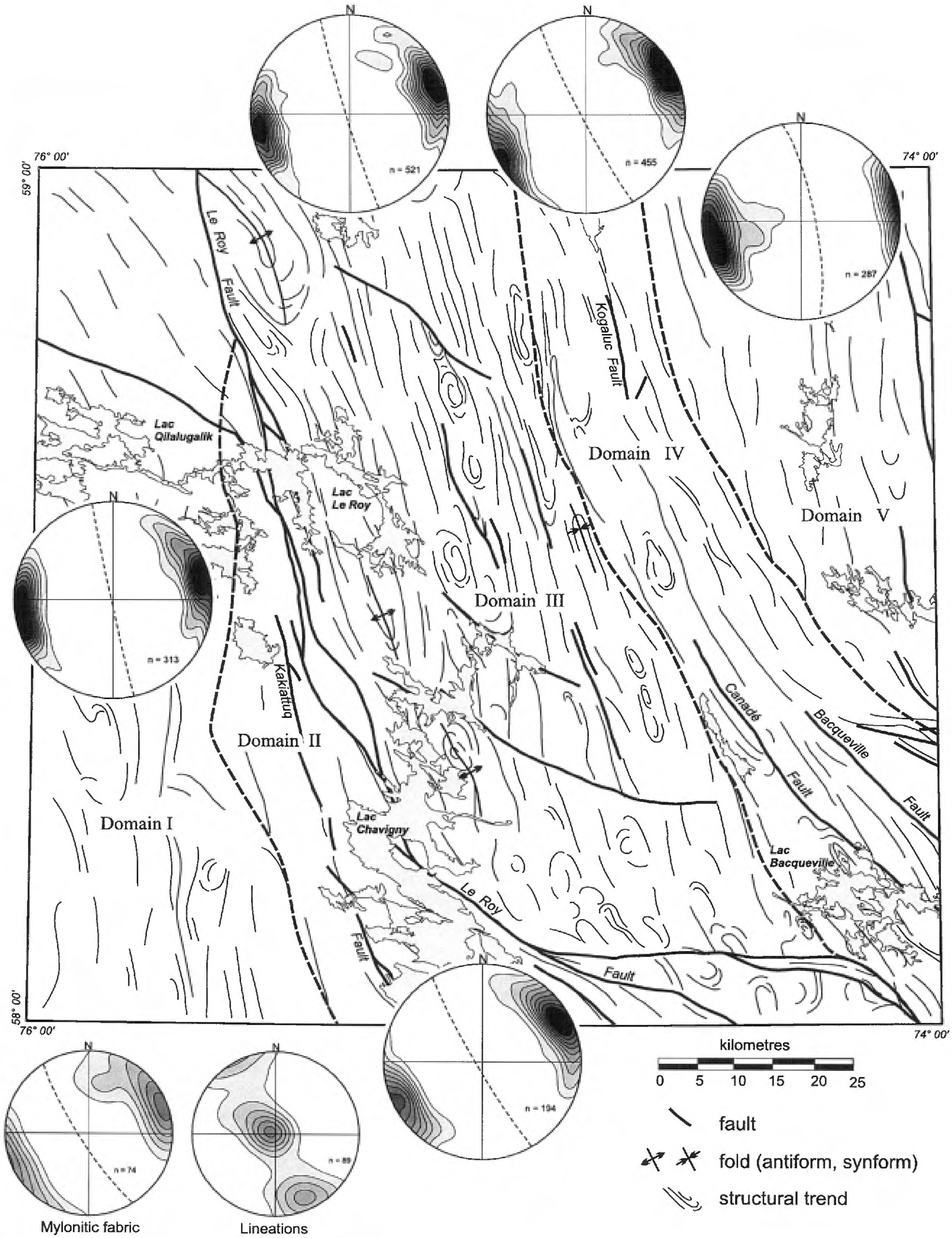


FIGURE 5 - Stereographic projections of the main foliation and tectono-metamorphic lineations in the Lac Vernon area (n = number of measurements).

makes it difficult to conduct a coherent structural analysis of S_0 surfaces and determine stratigraphic facing directions.

The dominant planar fabric in the Lac Vernon area is a penetrative foliation that is generally well developed in all lithologies, except for rocks of the Qullinaaraaluk Suite and diabase dykes. It is defined by the preferential orientation of biotite, hornblende, sillimanite and pyroxene, as well as quartz ribbons and lenses. The foliation is also represented in certain locations by migmatitic layering, gneissosity, and locally by the alignment of flattened clasts in conglomerates. The principal foliation, which is steeply dipping, is conformable with lithological contacts. This foliation is identified as an S_2 fabric, in accordance with the structural scheme based on cross-cutting relationships observed in certain supracrustal belts (see Lin *et al.*, 1995, 1996; Percival *et al.*, 1995b). In fact, the presence of a pre-D_2 foliation was observed in relatively weakly recrystallized conglomeratic blocs of the Vizien Complex (Lin *et al.*, 1996). Deformation D_2 overprints structures associated with D_1, and almost completely obliterates them.

Structural domains III and V are characterized by the presence of several elliptical structures with their long axis oriented parallel to the regional structural trend, and reaching up to about 10 km long. Within the large plutonic masses, these elliptical structures are outlined by lineaments of a ductile nature, observed on 1:50,000 scale topographic maps and aerial photographs. Some of these structures also appear on the geological map (Figure 4), namely in the Le Roy Complex. In the centre of this complex, an elliptical structure roughly 8 km in size corresponds to an enderbite core surrounded by conformable sheets of granite and diatexite. Further south, another similar structure stands out, outlined by the concentric distribution of diatexite and granodiorite units. These two examples may be explained by the development of structural domes, a doming effect coeval with the emplacement of plutonic rocks and D_2 deformation. In the Lac Minto area further south, similar elliptical structures are mainly associated with early intrusions of gabbro and diorite (Percival *et al.*, 1990).

The dominant S_2 foliation is folded, reoriented and locally truncated by subsequent phases of deformation. The structural analysis of foliation S_2 indicates a dominant strike direction ranging from NW-SE to N-S, for all structural domains (Figure 5). Stereograms provide a broad portrait of average strike directions for foliation S_2, ranging between N329° and N348°, with generally steep to locally moderate dips. Stereograms for structural domains I, III and V outline an essentially NNW-SSE orientation, whereas those for domains II and IV indicate an orientation closer to NW-SE. It is interesting to note that the nature of lithologies appears to control, at least in part, the foliation direction. For example, the foliation in the three domains dominated by plutonic rocks (domains I, III and V) is more northward oriented, whereas the foliation in the other two domains, which contain volcano-sedimentary rocks and tonalites, is closer to a NW direction (domains II and IV). The same phenomenon can be observed at the scale of the entire northeastern Superior Province.

Mineral lineations developed during phases of deformation D_2 and D_3. They are defined by the alignment of mineral aggregates and by elongate minerals such as hornblende, biotite, quartz and plagioclase. The poles to mineral lineations and fold axes form two distinct groups distributed along a great circle oriented N152°/83°, essentially parallel to the regional structural trend (Figure 5). Based on field observations, subvertical down-dip lineations are associated with phase D_2, whereas lineations moderately plunging towards the SSE are associated with deformation D_3. Lineations associated with deformation D_2 are essentially subparallel to the fold axes of F_2 folds.

Phase of deformation D_3 is characterized by upright tight to isoclinal folds oriented WNW-ESE to NNE-SSW without an associated axial plane schistosity. These mesoscopic to megascopic-scale F_3 folds are easily detected on outcrop and on the map, since they are produced by the folding of lithological contacts and S_2 foliation. In areas underlain by plutonic bodies, aerial photographs exhibit a few open folds which may correspond to deformation D_3. The variable configuration of F_3 folds is probably due to a difference in the rheological properties of volcano-sedimentary units versus plutonic units. F_3 fold axes plunge moderately towards the south. In the north part of domain III, the western limb of a major F_3 fold is truncated by a regional-scale fault (Le Roy fault).

Rocks in the Lac Vernon area were also locally affected by a relatively intense shearing episode. Volcano-sedimentary rock sequences in the Kogaluc and Chavigny complexes are segmented by ductile-brittle faults that extend for several kilometres. Similar shear zones were also documented in map areas adjacent to the Lac Vernon area (Parent *et al.*, 2000; Leclair *et al.*, 2001a). The development of these shear zones is attributed to phase of deformation D_4. These zones, one to ten metres wide, mainly consist of mylonites and locally of cataclasites. Mylonitic fabric S_4 strikes NNW-SSE and has a steep dip, whereas stretching lineations generally have a shallow plunge. S_4 has transposed the dominant S_2 foliation and lithological contacts. Most kinematic indicators related to the mylonitic fabric, such as C/S fabrics and asymmetric drag folds, suggest an apparent dextral strike-slip movement (Lin *et al.*, 1995; Parent *et al.*, 2000). However, a subvertical component of movement was also recognized along fault segments oriented WNW-ESE to E-W (Lin *et al.*, 1995).

At least five major faults in the Lac Vernon area are most likely associated with phase of deformation D_4, namely the Le Roy, Kakiattuq, Bacqueville, Canadé and Kogaluc faults (Figure 5). The Le Roy fault is an important structure that transects the west-central part of the area from north to south. This fault coincides with a major aeromagnetic discontinuity (figures 3 and 5), and marks the western boundary of structural domain III (Figure 5). It is oriented NNW-SSE in the north, then follows an arcuate path and takes on an E-W orientation in the south. The Le Roy fault is represented by a mylonitic fabric (Appendix 2; photo 1) along the NNW-SSE segment, and by cataclasites and pseudotachylites along the E-W segment. The Kakiattuq fault is represented by strongly deformed volcano-sedimentary rocks of the Chavigny Complex and tonalites of the Kakiattuq Suite. This fault, which extends southward into the adjacent map area, follows a path similar to the Le Roy fault. Based on a preliminary interpretation of structural and chronological relations, the Kakiattuq fault is inferred to represent a detachment zone separating rocks of the Chavigny Complex from surrounding tonalites. More detailed fieldwork is however necessary to confirm this hypothesis. In the easternmost part of the map area, a positive aeromagnetic signature is bounded by the Bacqueville fault to the east, and by the Canadé fault to the west (figures 3 and 5). These two faults extend towards the southeast into the adjacent Lac La Potherie area (Leclair *et al.*, 2001a). They may also correspond to the southward extension of the Kogaluc fault, associated with sheared rocks in the Kogaluc Complex (Figure 5). The Kogaluc fault is characterized by textural variations ranging from an ultramylonite to a cataclasite, typical of a deformation regime at the ductile-brittle transition. This fault, oriented NNW-SSE, is the result of dextral strike-slip movement. It exhibits a kinematic link with thrust-related structures essentially oriented E-W (Percival *et al.*, 1995; Lin *et al.*, 1995). Overall, geometric and kinematic relations of D_4 faults probably reflect the influence of a regional transpression-driven regime. Preliminary analysis of the geometry of major structural discontinuities, interpreted from the magnetic map, also supports the hypothesis of a transpression-driven regime (Leclair, 2001).

A phase of deformation D_5 was recognized in areas to the east of the Lac Vernon area (Parent *et al.*, 2000; Leclair *et al.*, 2001a). This deformation locally shows up as upright open folds oriented E-W, and as a slight undulation of the foliation and lithological contacts. The effects of deformation D_5 were not observed in outcrop in the study area.

Phase of deformation D_6 is responsible for the development of a major network of late faults that transect all units in the map area, including certain Proterozoic dykes. These faults correspond to aeromagnetic and topographic lineaments mainly oriented E-W to NW-SE. They are locally accompanied by subsidiary faults (fractures) oriented N-S, and are all typically brittle in nature. In outcrop, they form one to ten-metre-wide zones composed of cataclasite with local pseudotachylite. In a few rare locations, mylonitic fabrics are fractured and are largely obliterated by brittle deformation. This suggests that brittle deformation D_6 overprints early ductile structures. Most faults associated with D_6 coincide with alteration zones rich in hematite, chlorite and epidote. It is possible that certain or all of these faults are Archean in age, and that they were reactivated and percolated by hydrothermal fluids during brittle deformation D_6. Diabase dykes are locally affected by brittle D_6 structures (Appendix 2; photo 2). This suggests that certain brittle structures were active during the Proterozoic, since the oldest diabase dykes in the area are dated at 2230 Ma (Buchan *et al.*, 1998).

LITHOGEOCHEMISTRY

A lithogeochemistry study was conducted to broadly characterize the composition of volcano-sedimentary rocks of the Chavigny Complex, sedimentary rocks of the Le Roy Complex and the main lithodemic suites of plutonic rocks in the Lac Vernon area. To do so, 66 samples from various lithologies were collected and analyzed. All samples were analyzed for major elements and certain trace elements, and 33 of these were also analyzed for trace elements and rare earth elements (REE). Major element analyses and certain trace element analyses (Ga, Nd, Rb, Sr, Y and Zr) were performed at the Consortium de Recherche minérale du Québec (COREM) by X-ray fluorescence, and the remaining trace elements and REE were analyzed at the GEOLABS laboratory by inductively coupled plasma mass spectrometry (ICP-MS). The results were integrated to the SIGÉOM database.

Supracrustal Rocks, Diorites, Gabbros and Ultramafic Rocks

Analyzed supracrustal rocks were selected in units of the Chavigny Complex (Achy1 and Achy2) and the Le Roy Complex (Aroy1). Since the rocks of the Kogaluc Complex have already been studied, the reader is referred to the work of Skulski *et al.* (1996) for more information on the characterization of volcanic rocks in this complex. Intermediate, mafic and ultramafic intrusive rocks were sampled in the Bacqueville (Abcv) and Qullinaaraaluk (Aluk) suites. The classification diagram of Winchester and Floyd (1977) (Figure 6b) shows that volcanic rocks of the Chavigny Complex (Achy1 and Achy2) have sub-alkaline basalt (48.0-52.2% SiO_2) and rhyodacite-dacite (67.7-73.6% SiO_2) compositions, whereas sedimentary rocks (Achy1 and Aroy1) have more intermediate and felsic compositions (55.5-66.8% SiO_2). Note that sedimentary rocks are plotted only for comparative purposes. The AFM magmatic discrimination diagram proposed by Irvine and Baragar (1971) (Figure 6a) indicates that basalts form a tholeiitic suite, whereas felsic rocks (Achy1) coincide with the field of calc-alkaline suites. Ultramafic rocks (Abcv and Aluk) show iron-depleted magnesium-rich tholeiitic signatures (Jensen diagram, not shown). Compositions for diorite, gabbro and gabbronorite intrusions (Abcv) plot along the boundary between calc-alkaline and tholeiitic fields (Figure 6a). Basalts exhibit low Zr/Y ratios (1.8-2.4) typical of tholeiitic rocks, whereas felsic volcanic rocks have very high Zr/Y ratios (7-8) characteristic of evolved magmatic suites with a high incompatible

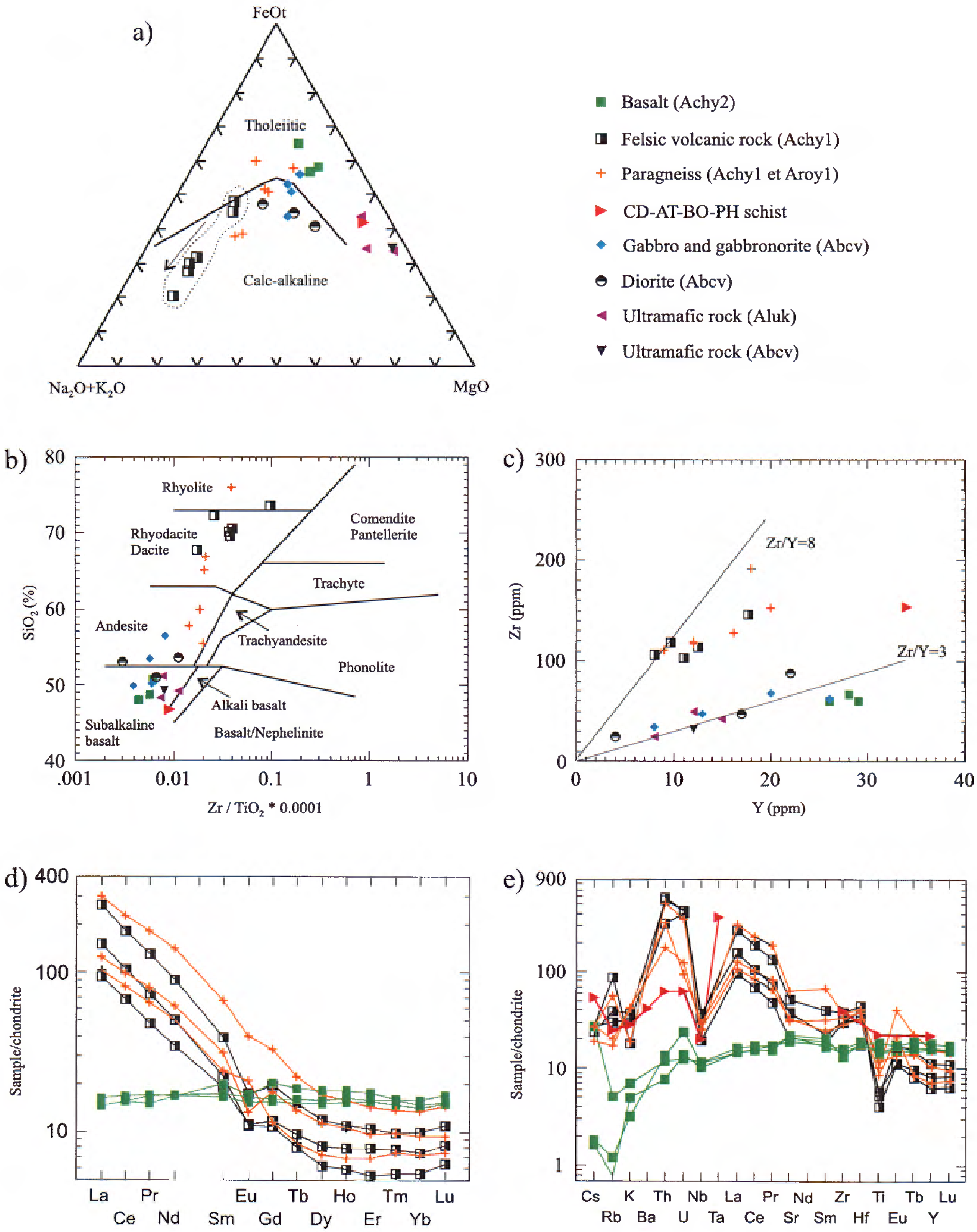


FIGURE 6 - Geochemical diagrams of supracrustal rocks and intermediate mafic and ultramafic intrusive rocks : **a)** AFM magmatic discrimination diagram by Irvine and Baragar (1971); **b)** SiO_2 versus Zr/TiO_2 classification diagram (Winchester and Floyd, 1977); **c)** Zr versus Y diagram; **d)** Chondrite-normalized rare-earth element diagram; **e)** chondrite-normalizer spiderdiagram (Sun and McDonaugh, 1989).

element content (Figure 6c). The chondrite-normalized REE diagram (Figure 6d) shows patterns for basalt, felsic volcanic and paragneiss samples. Basalts are characterized by flat patterns with a La/Yb ratio of 1 and lanthanum values 18 times chondrite. Felsic volcanic rocks (Achy1), on the other hand, are enriched in light rare earth elements and depleted in heavy rare earths relative to basalts. The felsic volcanic rocks underwent significant fractionation, as illustrated by their steep light rare earth patterns, with lanthanum values ranging from 100 to 300 times chondrite. The La/Yb ratio of felsic volcanic rocks ranges from 20 to 40. On the chondrite-normalized spiderdiagram (Figure 6e), felsic volcanic rocks show patterns characterized by La and Th enrichment, and Nb and Ti depletion. Differences between the patterns for basaltic and felsic volcanic rocks (Figure 6d and e), particularly in the heavy rare earth elements, lead us to consider two hypotheses: a) the felsic volcanic rocks are derived from a different source than the basalts, or b) the felsic volcanic rocks and the basalts come from the same tholeiitic source, but this source evolved through fractional crystallization to generate, first of all, basalts, and later on, felsic volcanic rocks.

Felsic Intrusions

The different suites of intrusive rocks were established based on field observations, lithological characteristics, feldspar staining, petrographic descriptions and magnetic signatures. Geochemical data corroborate these observations, since the vast majority of samples plot in the field of tonalites, trondhjemites and granites on the normative classification diagram proposed by O'Connor (1965) and modified by Barker (1979) (Figure 7a). Granites (Agdm and Aroy4) and granitized tonalites (Akkk2) are peraluminous, whereas hornblende tonalites (Akkk1), biotite tonalites (Akkk1) and enderbites (Aqil3 and Aroy2) straddle the metaluminous/peraluminous boundary (Figure 7b). With the exception of one granite sample, all analyzed suites have A/NK versus A/CNK ratios of less than 1, suggesting they are igneous in origin (I-type) and the product of magmatic differentiation. All samples show compositions typical of syn-collisional volcanic arc granitoids (Figure 7c). Hornblende tonalites of the Kakiattuq Suite are enriched in Y, suggesting they are derived from a more evolved source (Figure 7c). Figure 7 (d, e and f) contains a few diagrams showing variations in major element concentrations as a function of silica content. Most lithodemic suites show decreasing CaO and Al_2O_3 (Figure 7d and e), as well as Fe_2O_3t and TiO_2 (not shown), with increasing silica content, whereas K_2O increases along with silica. Granitized tonalites (Akkk2) show K_2O enrichment without any significant variation in silica content. This observation corroborates descriptions in the "Stratigraphy" section, which suggest most of the K-feldspar in tonalites of unit Akkk2 is secondary.

According to REE patterns, the tonalites, both hornblende and biotite-bearing varieties, show distinct geochemical signatures. Hornblende tonalites exhibit patterns similar to those of felsic volcanic rocks of the Chavigny Complex, *i.e.* a flat pattern for heavy rare earths, and significant fractionation of light rare earths (Figure 8a). Thus, the two lithologies may be the result of the same magmatic differentiation process. However, biotite tonalites and granitized tonalites exhibit patterns with much lower heavy rare earth concentrations. This leads us to consider the hypothesis that the two latter types of tonalite are derived from a less evolved magma than that which generated the hornblende tonalites. Granites of the Morrice Suite (Agdm) and the Le Roy Complex (Aroy4) show patterns similar to the biotite tonalites and granitized tonalites, albeit slightly more enriched in light rare earth elements (Figure 8b).

ECONOMIC GEOLOGY

Exploration by many different mining companies (Cominco, Soquem, Virginia Gold Mines and Cambiex) as well as mapping by the MRN has outlined the mineral potential of the Lac Vernon area. This section will briefly discuss the metalliferous potential of ultramafic intrusions of the Qullinaaraaluk Suite, known showings in the Kogaluc and Narsaaluk sectors, and anomalous occurrences detected during mapping in the Lac Vernon area.

Ni-Cu-Co-PGE Potential of Ultramafic Intrusions of the Qullinaaraaluk Suite

The discovery of the Qullinaaraaluk showing in the summer of 2000 sparked a new wave of interest for mineral exploration in Québec's Far North, mainly for Ni-Cu-Co-PGE occurrences. The showing is located south of the map area (NTS 34G10), about 225 km from Inukjuak and 125 km from Hudson Bay. This showing is associated with a new type of prospective setting for nickel, which had not yet been identified in Québec's Far North (Labbé *et al.*, 2000). It occurs in the Qullinaaraaluk Suite (Aluk) within an intrusion of massive ultramafic rocks composed of olivine pyroxenite with a few peridotite layers. This intrusion, which cross-cuts diatexites of the Lac Minto Suite (Amin1), is post-orogenic with regards to Archean deformation and metamorphism. The main zone of the Qullinaaraaluk showing consists of pyroxenite-hosted massive sulphides, composed of pyrrhotite, bravoite, pyrite, chalcopyrite and pentlandite (Labbé *et al.*, 2000). Samples from the massive sulphide zone yielded grades of 2.6% Ni, 1.8% Cu, 0.27% Co and 323 ppb Pt.

Mapping at 1:250,000 scale does not permit to show smaller mafic and ultramafic intrusions of the Qullinaaraaluk Suite on the map. However, non-mappable ultramafic intrusions, as well as the melanocratic facies of certain gabbros may constitute interesting targets in the search for Ni-Cu-Co-

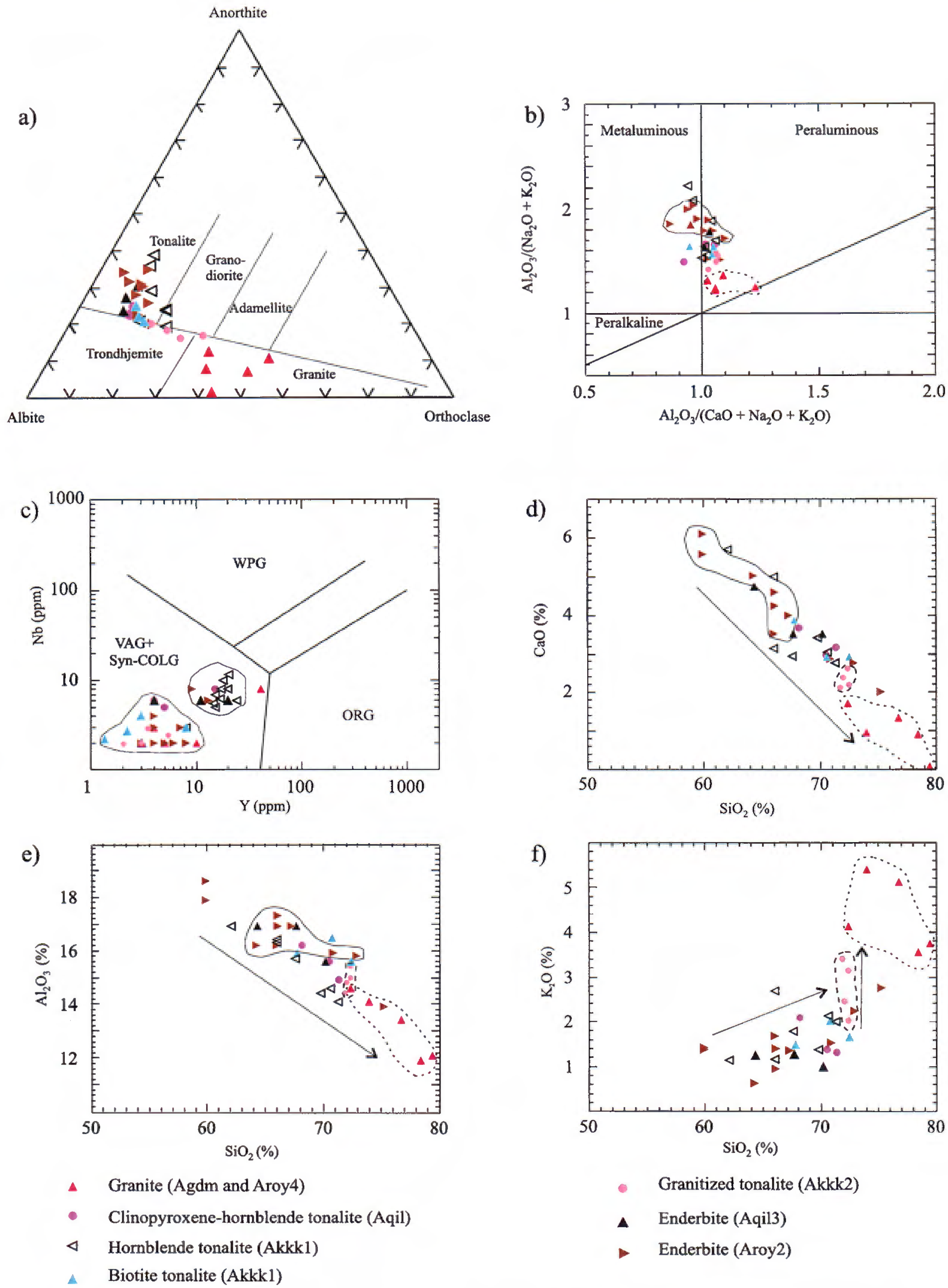


FIGURE 7 - Classification of the main intrusive suites in the Lac Vernon area : **a)** Normative anorthite-albite-orthoclase diagram by O'connor (1965) modified by Barker; **b)** Discrimination diagram by Maniar and Piccoli (1989); **c)** Tectonic setting discrimination diagram (Pearce *et al.*, 1984); VAG + Syn-COLG = Syn-collisional volcanic arc granitoid, WPG = within-plate granite, ORG = ocean ridge granite; **d) e) f)** Binary diagrams : CaO versus SiO_2, Al_2O_3 versus SiO_2, K_2O versus SiO_2.

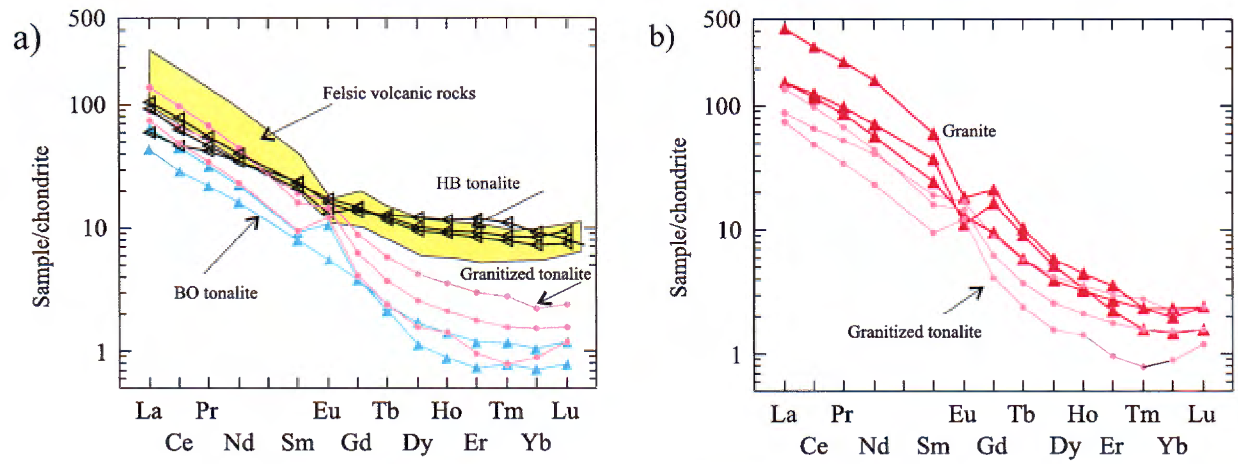


FIGURE 8 - Chondrite normalized rare earth element diagram. The legend is the same as in Figure 7. (BO = biotite; HB = hornblende)

PGE mineralization. Massive gabbros and gabbronorites found in the area may belong to a differentiated suite that also contains mineralized ultramafic layers. Figure 9 shows the distribution of outcrops dominated by undeformed gabbro, gabbronorite and/or ultramafic rocks.

Kogaluc Complex Sector

The Kogaluc Complex sector (Figure 10) was the focus of exploration work conducted by Soquem and Cominco as early as 1992 (Grosl, 1993). This work uncovered the presence of important gold mineralization associated with iron formations, some of which yielded grades reaching up to 61 g/t Au. Later on, Virginia Gold Mines concluded an agreement with Soquem and Cominco in order to carry out various surveys, namely stream sediment and soil sampling, ground and heliborne geophysics, mapping, channel sampling and drilling (Francoeur, 1995; 1996; Chapdelaine, 1998). The results of these surveys clearly demonstrated the gold potential of iron formations in the Kogaluc Complex. Figure 10 shows the location of the six main mineralized zones, and a few characteristic grades obtained from channel samples (Francoeur, 1995; 1996; Chapdelaine, 1998). In 1999, MRN metallogenists carried out reconnaissance work to characterize the iron formation-hosted gold occurrences (Lacoste and Labbé, 2000). The principal observations derived from this work are listed below:

Zones 1, 2, 3 and 4: Iron formations consist of thinly banded horizons with alternating oxide, silicate and chert beds. The silicates are granoblastic and consist of grunerite and hornblende with local garnet and epidote. Certain cm-scale horizons contain 5 to 30% sulphides, essentially pyrrhotite with less than 5% pyrite and traces of chalcopyrite and arsenopyrite. Gold grades obtained from these zones range from 1.0 to 5.7 g/t.

Zone 3: Felsic to intermediate horizons, somewhat unconformable and discontinuous, occur in association with other lithologies, namely iron formations, sediments and amphibolites. In this zone, the iron formations are characterized by the abundance of epidote and garnet (Appendix 2; photo 4). This late modification does not appear to be related to the gold mineralization. Samples from this zone yielded assays from a few ppb to 2 g/t Au.

Zones 4 and 6: Iron formation horizons are more continuous and of m-scale. They occur within a sequence of sedimentary rocks injected by tonalite and granodiorite. In these zones, the gold mineralization is not solely associated with the iron formations, since grades ranging from 3 to 5 g/t Au were also detected in strongly sheared biotite-garnet paragneiss bands. These bands are intensely silicified, and also contain sulphides.

Gold occurrences associated with the Kogaluc Complex appear to be controlled by late structures. Two episodes of mineralization are interpreted: a) syn-metamorphic disseminated mineralization, mainly concentrated in fold hinges, and b) gold remobilization along N-S shear zones (Appendix 2; photo 5). Results of work by Lacoste and Labbé (2000) indicate that the gold occurrences associated with iron formations are not concentrated in a specific facies. However, these authors note that the main ore guides are the presence of sulphides as well as late structures that remobilized the gold. Gold occurrences in the Kogaluc Complex are believed to be comparable to the Lupin mine (Northwest Territories), the Musselwhite mine (Ontario) as well as the Marvel Loch and Nevoria deposits in the Yilgarn Block (Australia).

Showings in the Narsaaluk Sector

Showings in the Narsaaluk sector occur in the southwestern part of the area (NTS 34J07) (Figure 4), and were discovered by Soquem and Virginia Gold Mines (Francoeur, 1998). They are hosted in a band of supracrustal rocks, composed of paragneiss and iron formation, assigned to unit Aroy1. This band extends over nearly 8 km long by a few hundred metres wide. The paragneisses are migmatitic,

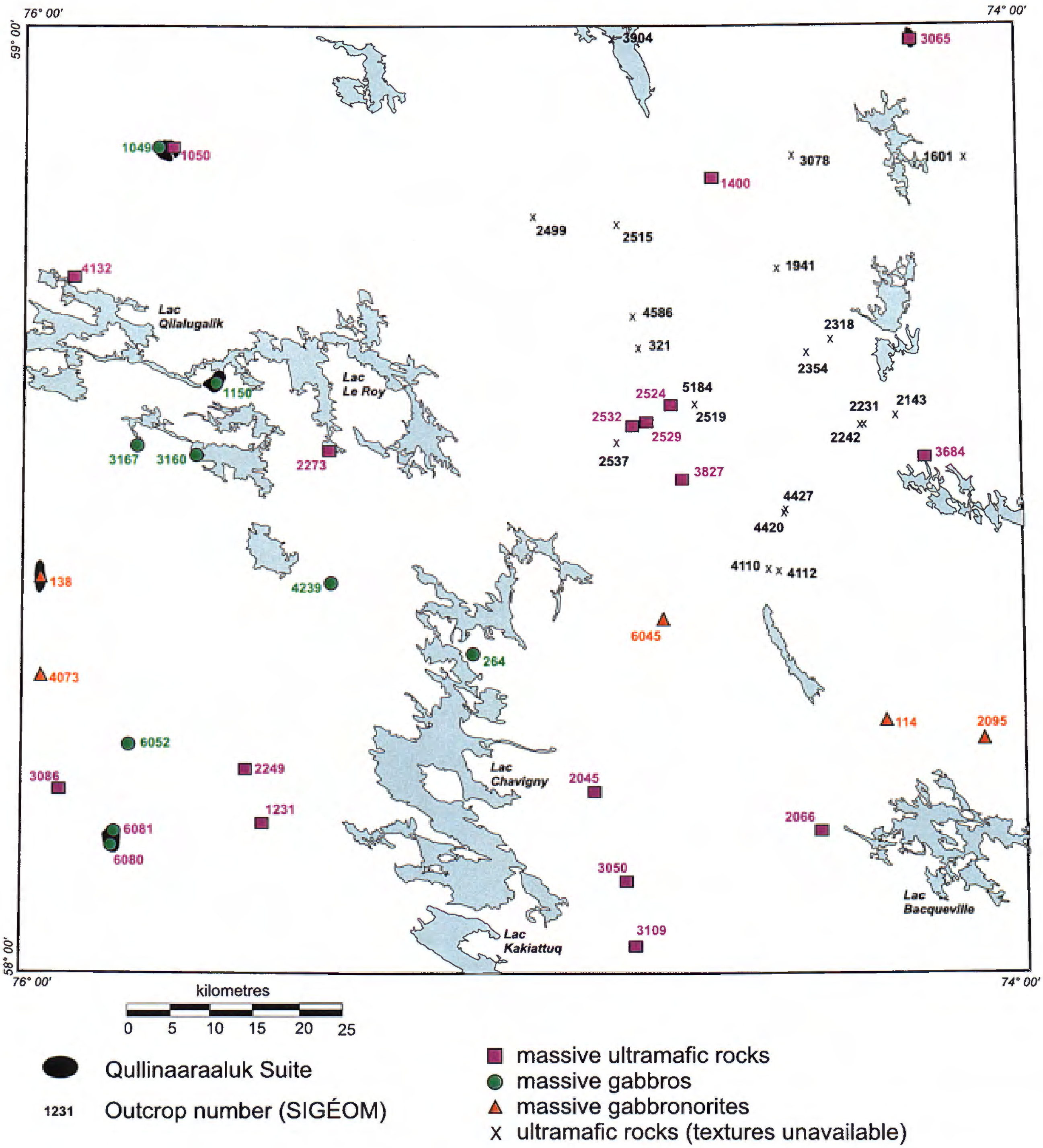


FIGURE 9 - Distribution of intrusions of the Qullinaaraaluk Suite and of non-mappable massive ultramafic rocks, gabbros and gabbronorites.

with up to 25% mobilizate. The iron formations are thinly banded, with on the one hand, mm-scale bands of magnetite and quartz, and on the other hand, quartz and pyroxene bands. The rocks were strongly recrystallized under conditions of granulite-facies metamorphism, and are strongly recrystallized. Work by Virginia Gold Mines, Soquem and Cambiex (Francoeur, 1998; Villeneuve and Chapdelaine, 1999) demonstrated that the gold potential of supracrustal rocks in the Narsaaluk area extends over more than six kilometres along strike. The best gold grades appear to be associated with the presence of garnet and biotite; the latter may indicate the presence of an alteration facies. A garnet-biotite paragneiss containing about 1% pyrite yielded grades of 7.0 g/t Au, whereas a slightly rusty iron formation,

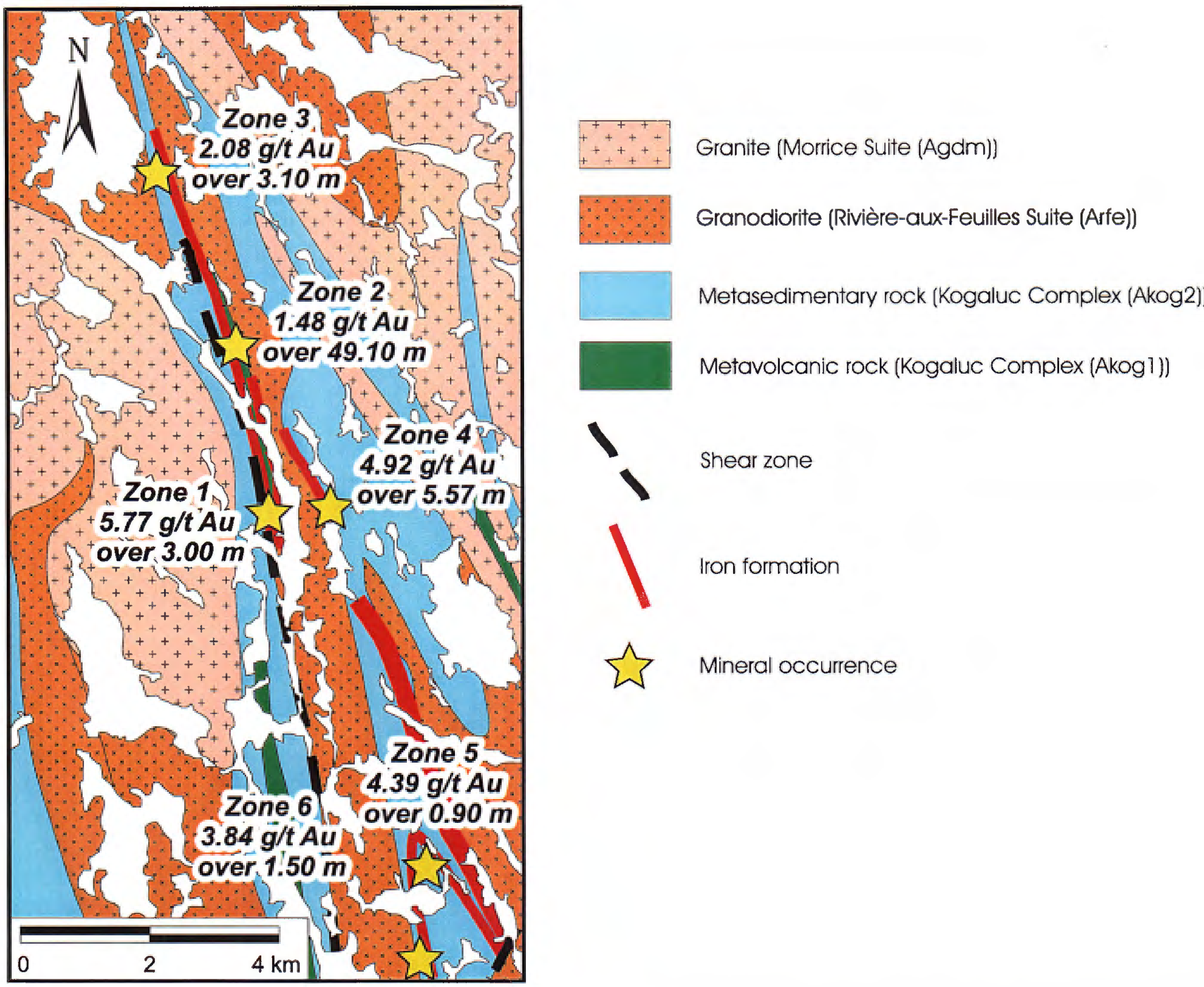


FIGURE 10 - Geology of the Kogaluc Complex sector (modified after Percival *et al.*, 1995a), along with a few gold grades characterizing the six main mineralized zones.

containing up to 50% garnet and traces of disseminated pyrrhotite, yielded grades reaching up to 7.9 g/t Au.

The sector in the immediate vicinity of the Narsaaluk showing also has a good potential for Ni-Cu-Co-PGE mineralization, considering the fact that Francoeur (1998) reported the presence of a gabbroic intrusion roughly 500 to 1000 m wide. This intrusion, composed of olivine gabbro, pyroxenite and possibly troctolite (Francoeur, 1998), shows certain features similar to those observed at the Qullinaaraaluk showing. Pyroxenite samples from the Narsaaluk sector yielded assay results of 0.26% Cu, 46 ppb Pt and 33 ppb Pd (Francoeur, 1998).

Anomalous Occurrences

Mapping conducted in the Lac Vernon area led to the discovery of six new sites with anomalous grades in gold and base metals. All these sites occur in supracrustal rocks of the Chavigny Complex (Achy) and in paragneisses (M4a). These occurrences (numbered 1 to 6), are briefly described in Table 1. Their location is shown on GC-type geological maps in the SIGÉOM system.

Chavigny Complex: Volcanogenic Hydrothermal Alteration Zone

In the northern part of the Chavigny Complex, cordierite-anthophyllite-garnet-biotite-phlogopite schists (Appendix 2; photo 6) occur at the interface between basalts (Achy2) and felsic volcanic rocks (Achy1). In Figure 6a, these schists clearly plot in the field of basaltic rocks (46.7% SiO_2). This alteration is characterized by enrichment in K_2O (1.85%), MgO (15%) and Al_2O_3 (17.5%), whereas Na_2O (0.18%) and CaO (0.43%) are leached from the rock. On the

TABLE 1 - Characteristics of the main mineral occurrences where anomalous grades in Au, Ag and base metals were detected.

	ANOMALOUS ZONES		SETTINGS	CONTENTS
1)	AL-00-172	475042 E 6474050 N	Anthophyllite-cordierite-biotite schists associated with felsic volcanic rocks and metaconglomerates.	600 ppm Cu, 250 ppb Au
2)	MP-00-1306	474974 E 6469293 N	Anthophyllite-cordierite-biotite schists associated with felsic volcanic rocks (tuffs?). The mineralization consists of disseminations of small stringers of pyrite and pyrrhotite.	0.14 % Pb, 0.20 % Zn, 4.2 ppm Ag
3)	MP-00-1239	476650 E 6443690 N	Silicate-facies iron formation associated with amphibolites (metabasalts?). The mineralization consists of 5 to 10 % euhedral to subhedral pyrite.	0.15 % Cu, 130 ppb Au
4)	AL-00-129	478502 E 6435935 N	Volcano-sedimentary rock sequence including alternating felsic and mafic volcanic rocks, and paragneisses. The mineralization consists of disseminated pyrite hosted in a siliceous horizon.	99 ppb Au, 0.18 % Zn, 5.4 ppm Ag
5)	JV-00-4080	481809 E 6429912 N	Ultramafic horizons associated with garnet-graphite paragneisses and silicate-facies iron formations. Magnetite veinlets are observed in the ultramafic rocks.	0.12 % Ni
6)	AL-00-0224-A3	474806 E 6429034N	Silicate-facies iron formation associated with paragneisses. It is exposed over more than 100 metres in width. The compositional banding, very well developed, contains pods of garnet and magnetite.	340 ppm Cu, 180 ppb Au

spiderdiagram (Figure 6e), these schists exhibit patterns similar to Achy2 basalts, despite a proportional increase in mobile elements. Furthermore, these schists do not exhibit a negative titanium anomaly, typical of felsic volcanic rocks (Figure 6e). These similarities in the chemistry of schists and basalts may indicate a genetic link between the two lithologies. Furthermore, anomalies in Pb (0.14%), Zn (0.20%), Ag (4 ppm) and Au (250 ppb) were detected in siliceous horizons associated with the schists. The presence of altered basalts and base metal anomalies suggests the existence of an environment favourable to the presence of volcanogenic hydrothermal mineralization (Labbé and Lacoste, 2001).

CONCLUSION

The results of mapping carried out in the Lac Vernon area helped establish a geological framework at 1:250,000 scale, and define its stratigraphic, structural and geochemical parameters. The rocks in the area reflect a complex geological history marked by a succession of magmatic and tectonic events bracketed between 2770 and 2680 Ma. The lithodemic subdivision proposed in this report is based on the lithological characteristics of the different units, on cross-cutting relationships observed in the field and on radiometric ages. This subdivision will eventually be used to establish stratigraphic correlations for the entire northeastern Superior, by avoiding the constraints, in a preliminary phase, of pre-established tectonic models. This approach led to the definition, in the Lac Vernon area, of three lithodemic complexes that contain supracrustal rocks, eight intrusive suites, and an undifferentiated lithological unit. These Archean units are cross-cut by post-orogenic diabase dykes which may belong to the Maguire (*ca.* 2230 Ma) and Minto (1998±2 Ma) dyke swarms.

The oldest rocks in the area are the tonalites of the Rochefort Suite (2769+6/-4 Ma), found in small pockets in the eastern part of the map area. Inherited zircons recovered from a tonalitic sample of the Qilalugalik Suite also indicate the presence of crustal remains at *ca.* 2780 Ma. The Kogaluc Complex, the largest expanse of supracrustal rocks in the area (8 x 110 km), contains mafic, intermediate and felsic volcanic rocks, pyroclastic rocks, greywackes, sandstones, siltstones, argillites and iron formations. The volcanic rocks in this complex, dated at *ca.* 2759 Ma, represent both evolved calc-alkaline suites and less widespread tholeiitic suites.

Further west, homogeneous biotite and hornblende tonalites of the Kakiattuq Suite are characterized by two distinct geochemical signatures. Biotite tonalites were dated at 2740±4 Ma, whereas hornblende tonalites appear to be genetically related to felsic volcanic rocks of the Chavigny Complex, dated at 2722±2 Ma. Furthermore, along the borders of these tonalite intrusions, a granitization phenomenon generated interstitial K-feldspar, isolated microcline phenocrysts and injections of granitic material. This granitization process appears to have occurred in two distinct phases. The granitic injections suggest emplacement coeval with tonalitic magmatism, *i.e.* syn-magmatic and syn-D_2 deformation, whereas the presence of interstitial K-feldspar indicates late K_2O input relative to tonalite crystallization and D_2 deformation. K_2O input may be related either to D_4 shearing, or the emplacement of late granites.

In the centre of Kakiattuq tonalites, outcrops the Chavigny Complex (1 km x 30 km) characterized by the predominance (nearly 70%) of felsic volcanic rocks, composed of rhyolite and rhyolitic tuff (2722±2 Ma). It also contains basalts, sericite schists, greywackes, pelites, iron formations, polygenic conglomerates and anthophyllite-cordierite schists. The results of a broad geochemical study of volcanic rocks of the Chavigny Complex suggest that the felsic volcanic rocks and the basalts may be derived from the same tholeiitic source. The latter is believed to have evolved through the production of basaltic magmas, to eventually yield calc-alkaline rhyodacitic rocks. The presence of a single evolution series for all volcanic rocks in the Chavigny Complex is corroborated by field relations observed between basalts and rhyolites, as well as the presence of volcanogenic hydrothermal alteration, suggesting coeval and bimodal volcanism.

The Qilalugalik Suite is characterized by tonalites (2709±3 Ma), granites and enderbites that correspond to an irregular positive aeromagnetic pattern located in the western part of the map area. The presence of this suite marks the eastern boundary of a plutonic domain that possesses all the aeromagnetic, lithological and geochronological characteristics of the "Tikkerutuk Domain" and the Bienville Subprovince.

The Le Roy Complex, on the other hand, is characterized by alternating units of diatexite, granite, enderbite and paragneiss, and the entire assemblage exhibits a striated magnetic signature. Gradual and transitional contacts between migmatitic paragneiss, diatexite and granite suggest a genetic link between these rock types. Enderbite emplacement, probably coeval with the Qilalugalik Suite (2709±3 Ma), was likely accompanied by a rise in the geothermal gradient. The latter is believed to have been sufficient to induce partial melting in paragneisses and generate diatexites (2698 Ma) and granites. Furthermore, the sporadic distribution of orthopyroxene and the presence of diffuse granodioritic phases in enderbites of the Le Roy Complex are most likely related to variations in H_2O and CO_2 contents in the magma. The assimilation of paragneisses constitutes a potential source of hydrated material, which may explain the increase in volatile content, and cause the breakdown of orthopyroxene. Originally, the Le Roy Complex probably formed a sedimentary basin along the margin of volcano-sedimentary sequences of the Kogaluc Complex.

The Lac Vernon area contrasts with surrounding map areas due to its relatively well-developed NNW-SSE structural trend. This trend is generally expressed as a typically striated magnetic pattern, and by a vast majority of units oriented parallel to the dominant foliation. The foliation, present in most lithologies with the exception of rocks of the Qullinaaraaluk Suite and diabase dykes, is attracted by at least two phases of folding (D_2-D_3) as well as an episode of relatively intense shearing (D_4), which enhanced the regional structural trend. Elliptical structures observed in the central part of the area locally disturb the principal foliation. The geometry and distribution of these ovoid structures suggests the presence of structural domes, a doming effect associated with magmatic deformation coeval with episode D_2. The development of a mylonitic fabric and several major faults associated with the shearing event (D_4) is largely responsible for the dismemberment of units and for several major aeromagnetic discontinuities. Hence, these faults played a significant role in the distribution of broad lithological assemblages and aeromagnetic patterns. Episode of deformation D_5, observed in adjacent areas, was not identified in the Lac Vernon area. Finally, brittle deformation (D_6) locally affects diabase dykes of the Maguire (*ca.* 2230 Ma) and Minto (1998±2 Ma) swarms, implying that certain structures related to this deformation were active even after the Archean.

Mapping conducted in the summer 2000 helped to outline the mineral potential of the Lac Vernon area, namely with the discovery of a significant Ni-Cu-Co showing in a late pyroxenite and peridotite intrusion (Qullinaaraaluk showing) located in the Lac Minto area to the south (NTS sheet 34G). Similar ultramafic and mafic rocks (Qullinaaraaluk Suite) occur in many locations in the Lac Vernon area. Elsewhere, the Chavigny Complex contains anthophyllite-cordierite zones associated with volcanic rocks, which yielded anomalous gold and base metal assay results. These zones are interpreted to represent alterations of volcanic rocks, and therefore represent a prospective environment for volcanogenic mineralization. Finally, the gold potential of the area had already been demonstrated in the Kogaluc and Narsaaluk iron formations, where grades reaching up to 61 g/t Au were found in recent exploration programs conducted by Soquem, Cominco, Virginia Gold Mines and Cambiex.

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APPENDIX 1 : PHOTOGRAPHS

Photo 1 - Effect of the granitization process; development of isolated K-feldspar phenocrysts within the tonalite (Akkk2).

Photo 2 - Felsic tuff in unit Achy 1 showing primary compositional banding.

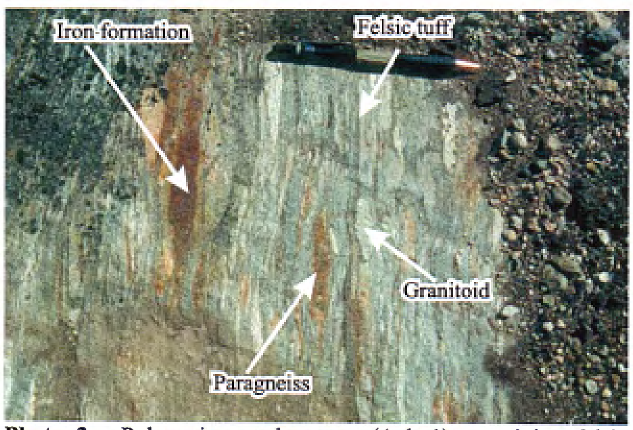

Photo 3 - Polygenic conglomerate (Achy1) containing felsic volcanic rock, iron formation, paragneiss and granitoid clasts.

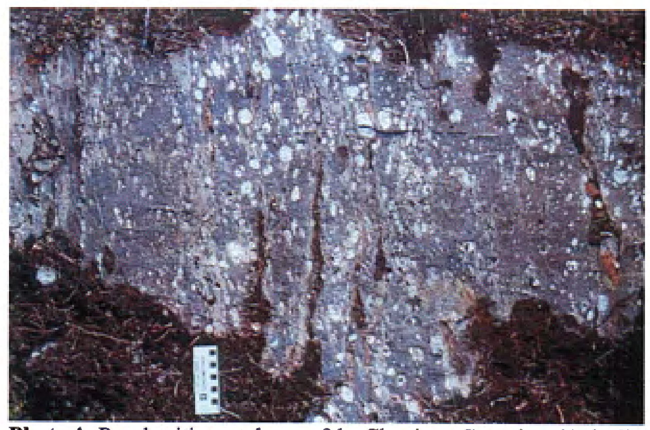

Photo 4 - Porphyritic metalavas of the Chavigny Complex (Achy2).

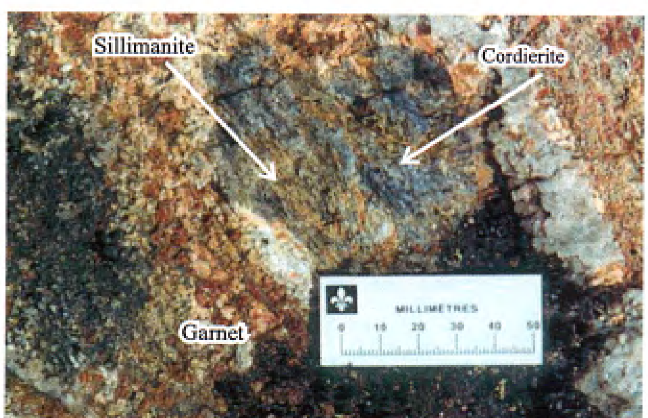

Photo 5 - Garnet-biotite-cordierite-sillimanite diatexite of the Le Roy Complex (Aroy3).

Photo 6 - Heterogeneous enderbite (Amin5) with injections of charnockitic material having diffuse contacts.

APPENDIX 2 : PHOTOGRAPHS

Photo 1 - Mylonitic fabric associated with phase of deformation D_4.

Photo 2 - Diabase dyke affected by brittle deformation D_6.

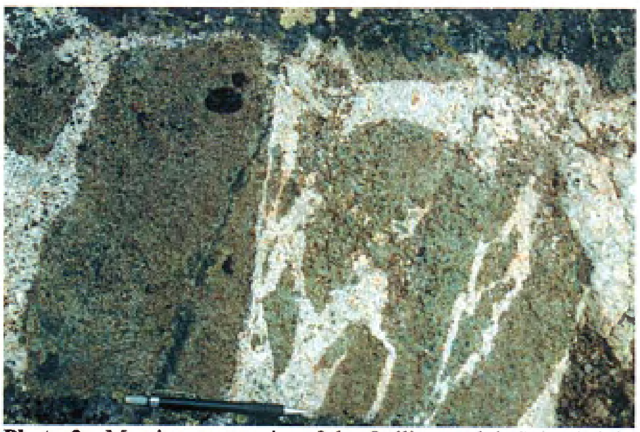

Photo 3 - Massive pyroxenite of the Qullinaaraaluk Suite (Aluk) injected by tonalitic material.

Photo 4 - Epidotized iron formation in the Kogaluc sector.

Photo 5 - Mylonitic fabric (D_4) overprinting bands and folds in iron formation of the Kogaluc sector.

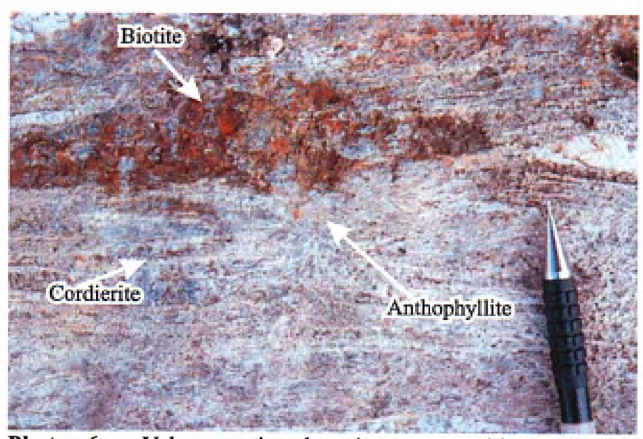

Photo 6 - Volcanogenic alteration zone with cordierite, anthophyllite, biotite and phlogopite.

Abstract

The Lac Vernon area, bounded by latitudes 58°00' and 59°00' north and longitudes 74°00' and 76°00' west, is represented by NTS sheet 34J. It covers a surface area of about 13,000 km. The centre of the area is located 175 km east of the community of Inukjuak, and about 140 km from the coast of Hudson Bay. The geological survey carried out at 1:250,000 scale was conducted within the scope of the Far North mapping project spearheaded by Géologie Québec.

Archean rocks in the Lac Vernon area were subdivided into different lithological and lithodemic units. Volcano-sedimentary rocks are concentrated in the Chavigny (2722 Ma) and Kogaluc (< 2759 Ma) complexes, whereas sedimentary rocks in the central part of the map area were grouped in the Le Roy Complex. Elsewhere, a few bands several kilometres in size, mainly composed of paragneiss with a few mafic gneiss outcrops were grouped in a lithological paragneiss unit. Tonalitic rocks belong to the Rochefort (2769 Ma) and Kakiattuk (2740 Ma) suites, whereas foliated and granoblastic gabbros, diorites and gabbronorites are associated with the Bacqueville Suite. Granodiorites of the Rivière-aux-Feuilles Suite (2722 Ma) are found in the vicinity of the Kogaluc Complex, as well as in the northwestern part of the map area. The other plutonic rocks are represented by the Qilalugalik Suite (2709 Ma), the Lac Minto Suite (ca. 2700 Ma), the Morrice Suite (2682 Ma), the Qullinaaraaluk Suite and the Le Roy Complex (2698 Ma).

The Lac Vernon area is characterized by the presence of five aeromagnetic patterns, with orientations ranging from N-S to NW-SE. Each of these anomalies is characterized by distinct lithological associations and different geological settings and structural styles. Rocks in the Lac Vernon area reflect a complex structural setting that results from two phases of ductile and folding deformation (D-D), a phase of intense shearing (D) and a phase of brittle deformation (D). A penetrative foliation (S) is present in all the rocks in the area with the exception of those of the Qullinaaraaluk Suite and diabase dykes. Ovoid shapes suggest the presence of structural domes (doming effect) whose formation is coeval with the emplacement of plutonic rocks and D deformation. The structural evolution is associated with pre- to post-tectonic intrusive events that mask contact zones between certain geological assemblages. It is also characterized by amphibolite and granulite facies regional metamorphism.

The economic potential of the area was namely outlined by the discovery of the Qullinaaraaluk Ni-Cu-Co showing located in the area that corresponds to the southern map sheet (NTS 34G). It consists of m-scale massive and semi-massive sulphide pods hosted in a late intrusion of pyroxenite and peridotite (Qullinaaraaluk Suite). Samples collected during the mapping campaign yielded grades reaching up to 2.6 % Ni, 1.8 % Cu and 0.27 % Co. Several mafic and ultramafic intrusions similar to the Qullinaaraaluk intrusion were mapped in the Lac Vernon area. Elsewhere, the Chavigny Complex contains anthophyllite-cordierite zones associated with volcanic rocks, which host anomalous gold and base metal grades. These zones appear to represent basalts affected by volcanogenic hydrothermal alteration. Finally, the gold potential of the area had already been confirmed in the Kogaluc and Narsaaluk iron formations. Grades reaching up to 61 g/t Au were obtained during exploration programs conducted by Soquem, Cominco, Virginia Gold Mines and Cambiex since 1993.

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